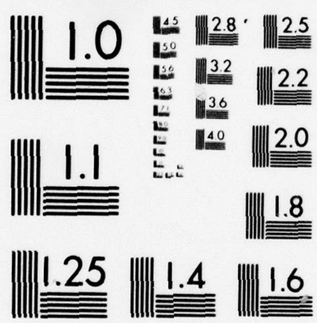

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

A TECHNICAL REPORT
FROM

The Laboratory for Social Research

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HEMISPHERIC LATERALIZATION AND SOCIAL COMPARISON.

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FORWARD

The research reported herein primarily represents studies conducted to determine particulars about instrumentation requirements for research utilizing scalp recorded electrical events as they relate to elements defined by the social matrix. The studies are substantively interesting, and the substantive content is what is reported.

The studies reported represent preliminary investigation and should be so viewed. As such, they suggest an interesting phenomenon which is reactive to social factors, and suggest the line of inquiry is feasible and potentially fruitful.

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I. INTRODUCTION

Our objective in this report is to demonstrate the feasibility of inquiry into the effect of social comparison situations on hemispheric lateralization. We present the procedures and the results, within a particular research setting, of several exploratory studies which taken together suggest that linkages can be demonstrated between lateralization and social variables.

Physiology dynamically reflects social interaction (Barchas, 1976). Research which demonstrates that position in the social structure is apt to elicit predictable physiological responses has focused mainly on aspects of interpersonal hierarchical structures. In this arena, there is sufficient evidence from our laboratory and others to show that hormonal physiological processes are altered by social life (Barchas and Barchas, 1975, 1977). There is evidence now that there are patterned relationships between the central nervous system and social behavior as well (Barchas, Ecker, Jose, Kopell, and Roth, 1975; Jose, 1977). This report focuses upon the effect of certain elements of social behavior on the lateralization of cerebral alpha activity.

A. Hemispheric Dominance and Lateralization

The human brain has two cerebral hemispheres, one on the right and one on the left, which are connected by a bundle of neurons called the corpus callosum. In humans, these two hemispheres exhibit functional specialization.[1] Information on hemispheric functioning has come from rich clinical studies on hemispherectomized and lesioned patients (Bogen, 1969a,b; Hecaen, 1962), from patients in whom the hemispheres have been separated (Sperry, 1974; Gazzaniga, 1970), and from animal work (Dimond

and Beaumont, 1974; Mountcastle, 1962). More recently, attention has been directed to intact-brain patients and to normally functioning individuals. These studies often have used the EEG to measure and record brain activity (Donchin, McCarthy, and Kutas, 1977).

The accumulated evidence strongly suggests that in the human each of the brain's hemispheres is functionally specialized (Milner, 1974). Left hemisphere activity is associated with certain cognitive tasks, while right hemisphere activity is associated with other types of tasks. In the intact brain of normal humans this hemispheric asymmetry of function is not an all-or-none affair; both hemispheres are simultaneously active for any given mental task. Functional asymmetry, or lateralization, refers to the relative activity of one hemisphere in comparison to the other.

For most normal, right-handed individuals the left hemisphere is specialized for analytic and logical processes, including speech and language functions, and mathematical operations. The specialization of the right hemisphere is interpreted to be superior for holistic and synthetic functions, including visual and spatial processes. Several labels characterizing the functional differences for the left versus right brain have been used: stimulus-response versus gestalt, algebraic versus geometric, analytic and sequential versus analogic and holistic, rational versus intuitive and emotional.

One large segment of lateralization research in normal people has directed attention to the question: "What are the hemispheres specialized for?" The approach to answering the question has been one of identifying correlations between activity in each hemisphere and various cognitive tasks. Virtually all of these studies have followed a single

experimental procedure (Butler and Glass, 1975; Doyle, Ornstein, and Galin, 1974; Galin and Ornstein, 1972; Osborne and Gale, 1976). A series of tasks is presented to a subject; some of these have been found to elicit predominantly left hemisphere activity. For example, typical "left hemisphere" tasks have been simple arithmetic and counting problems, spelling lengthy words, filling in missing letters or words, thinking of synonyms, writing letters, and similar activities. Tasks shown to be handled preferentially by the right hemisphere have included listening to music, recalling facial expression from photographs, arranging blocks and performing similar spatial tasks.[2] The expression of hemispheric dominance by task depends to some degree on the experience of the subject. For example, musicians are likely to go into a left hemispheric mode when hearing music, while nonmusicians favor the right hemisphere under the same conditions (McKee, Humphrey, and McAdam, 1973).

Our research focus is on the unexplored questions of shifts in hemispheric balance under varying social conditions, rather than on task-specific hemispheric activity. We hold cognitive task constant and vary the social conditions under which it is performed.

B. Measurement

Typically, in lateralization work, surface electrodes placed at homologous locations on the scalp pick up electrical cortical activity generated by the brain, as subjects perform tasks. The electrical impulses from each hemisphere are independently sent to an electroencephalograph (EEG) for amplification which permits measurement. Various researchers have favored different electrode placement, so that leads from the occipital, temporal, and parietal areas have been used (Donchin,

McCarthy, and Kutas, 1977; Lewis, 1977). Each of these cortical lobes receives sensory information from the body. In each, most of the area is devoted to "association cortex" (Teyler, 1975). We believe that the social conditions of interest will probably act on all the cortical areas of the brain. We claim no insight into the mechanisms by which this occurs. Rather, we seek to demonstrate the phenomenon. We have used the occipital areas for electrode placement because of the accessible location of the occipital, the reliability of measures taken from the occipital, and because our task stimuli are visual. We believe it to be a conservative choice in terms of potential reactivity.

EEG activity in the 8-13 Hz range (the alpha band) has been the measurement most consistently used to infer cortical activity. Alpha activity has been taken to represent the relative degree of waking restfulness of the brain; the greater the amount of alpha, the more restful the state (Walter, 1959). Hence, within a subject, relative mental activity has been inferred from a supression in the amount of alpha; differential levels in the amount of alpha in the two hemispheres allow inferences about hemispheric balance of activity (Morgan, Macdonald, and Hilgard, 1974).

C. Rationale

We believe that it is likely that the social situation is comprehended and acted upon differentially by the two hemispheres. At this point we believe that in normal functioning the special capacities of the right hemisphere are utilized as the individual orients to a social structure. We believe that the left hemisphere is utilized to rationalize, label and actualize these perceptions, according to the rules,

norms, valuations appropriate to that situation.[3] In summary, we believe that the left brain functions in part to rationalize the social structural perceptions of the right brain, translating the basic right brain perceptions of social structure into the cultural world of the actor.[4,5]

Most simply, we posit increased right-brain activity with increased social loading. By social loading, we mean the presence of perceivable social information and cues potentially relevant to the interaction situation in which the actor is engaged.

The dependent variables are constructed from measures of alpha production of each hemisphere taken from the occipital regions. These are used in the construction of two indices: an index of total alpha output, and one of lateralization of alpha. Although both indices are derived from the same empirical data, they reflect different aspects of task involvement. Total alpha is taken as an inverse indicator of mental engagement on the task. Lateralization of alpha is taken as an inverse indicator of relative hemispheric involvement which relates to the cognitive mode employed.

Analysis of total alpha permits us to assess whether it does vary in a patterned way relative to the social conditions. Analysis of hemispheric laterality relates directly to our conceptualizations concerning hemispheric balance.

Part II describes aspects of the design and execution of the research. We present the analysis of total alpha in Part III, which is followed by data bearing on our hypotheses about hemispheric shift in Part IV. The analysis in Part V takes into consideration the cognitive mode in which the subjects approached the task. Part VI consists of data summary and conclusions.

II. DESIGN AND OVERVIEW OF THE EXPERIMENTS

A. Task Selection

Not knowing *a priori* the magnitude with which we would be dealing, nor the sensitivity of measurement necessary to pick up such a right shift, and given our expectations associating social information with right-brain phenomena, we wanted a task which would not in and of itself elicit right-brain activity. We also wanted a task embedded in behavioral research.

Therefore, we pretested each of five standardized tasks used in the Laboratory for Social Research at Stanford University, with respect to their effects on alpha laterality. The tasks tested were the Relational Insight Task, the Spatial Judgment Task, the Meaning Insight Task and the two forms of the Contrast Sensitivity Task. From this pretest, we concluded that the Spatial Judgment Task, created and standardized by Ruth Cronkite, met our needs. (Despite its name and the free association of spatial orientation with right-brain activity, this task was performed by most subjects as a left-brain, analytic task.)

The Spatial Judgment Task is an ambiguous, binary-choice, decision-making task, developed for use in the Expectation States Research Program. In the trials of the Spatial Judgment Task, subjects view black-and-white photographic slide projections of postcard scenes, usually examples of European architecture, on each of which a white bar has been superimposed. In each trial, subjects are required to decide whether the length of the white bar is greater or less than a standardized measurement which the experimenter states. Although this task was designed and standardized to evoke estimates of "greater" or "less" at a probability of about 0.50,

subjects are led to believe that there are correct answers and that it is possible to perform well.

Before the studies reported here were initiated, a second pretest was conducted to validate our laboratory equipment and procedures by replicating alpha laterality results of other laboratories.

B. Laboratory Setting and Design

In practical terms, we desired a laboratory setting that would permit controlled manipulations, in which there were standards for assessment of our behavioral manipulations, and one where repeated readings of alpha would be possible while the subject was sitting quietly. To this end, we seized upon the two-phase experimental paradigm established by Berger and his colleagues (Berger, Conner, and Fisek, 1974) which has the desirable characteristics of a highly controlled setting with standards for reliability. We used this basic setting for each of the studies presented in this report.

In this well-documented experimental paradigm, the subjects performed a sequence of judgment tasks, giving an initial and final response on each trial. Alpha recordings from each hemisphere were taken while the subject was studying the slides.

In the experimental conditions, a subject is led to believe that he/she possesses a level of competence in comparison to a national standard and in comparison to a partner. A two-phase procedure was followed. In the first phase, subjects were performing as individuals (no social loading) making an initial and final choice. In the second phase, they performed the task under conditions of increased social loading. Prior to the second phase, they were a) put into a team situation by being

informed that they were now working with a partner, and b) they were put into a comparison situation by being informed of their performance relative to national standards and in comparison to the performance scores of their partner. Social loading was further increased in the final decision of this second phase by c) giving subjects feedback from their partners, for each trial, in the form of agreements or disagreements from the partner. These occurred after the initial and prior to the subject's final response.

For the control conditions, no manipulations were performed and the two-phase procedure was as follows. In the first phase, subjects performed as individuals, making an initial and final choice on each trial. The first phase is the same as in the experimental condition. After the first phase was completed, subjects in the control condition were allowed a brief rest period. The rest period corresponds to the point in the experimental condition when the social loading manipulations were made, and was of a similar duration. After the rest period, subjects again performed as individuals, making an initial and final choice without a national comparison group, partner performance comparison, or partner feedback.

For both types of conditions, the setting met our requirements for a serial task which can be performed individually by each subject while permitting repeated alpha measurements. For the experimental conditions, it met the requirement of increased social loading (in Phase II) while allowing subjects to be their own control (Phase I). Also, because of the elegant prior experimental and theoretical work from which the setting was created and in which it was embedded, we eventually can interpret the social loading manipulation in terms of expectation states theory. In so doing, subject responses (choices) could be used to relate hemispheric balance to choice behavior.

Several considerations entered into our choice of the specific status manipulation to be used in the setting. Our objective at the time was to manipulate the status position of an actor (subject) in relation to a partner, but in a way which maintained their status equality, so that observed changes in lateralization could be related to social loading unconfounded by differential status expectations between the actors.

Our criterion of status equality between the interactants left us with two manipulations from which to make our choice, the condition where both interactants are manipulated into a high status state (HH), or the condition where both are manipulated into a low status state (LL). We chose the high status manipulation (HH) because it seemed less likely to stress subjects participating in the study and seemed most appropriate for preliminary study.

C. EEG Equipment

Observations of occipital EEG alpha (8-13 Hz) amplitude from each hemisphere were obtained by a Grass Model 5 Polygraph with three Grass gold-cup scalp electrodes. Electrodes were attached to the scalp with Grass EC-2 electrode cream at the central vertex (C_z) as reference, and at each occipital region O_1 and O_2; a fourth, a ground, electrode was clipped to the earlobe. The EEG information from each occipital-vertex linkage was amplified by a Grass 5B amplifier with 5P5B or 5P5C preamplifier. An analog form of EEG was recorded by the chart writer for purposes of monitoring the occurrence of artifacts, such as eyeblink or 60 Hz interference. A second record of EEG information was taken from the amplifier by a Grass Model R5DC tape reverter and sent through a Med Associates, EEG 500 alpha bandpass filter. The alpha components of the

EEG signal were then processed through an analog-to-digital converter (Med Associates, ANL 940) and finally displayed in digital form on a multiple channel counter display (Med Associates DIG 800, with adjustable timer DIG 800A). The counter is built with a holding register which allows the summation and readout of standard units based upon microvolts of alpha activity produced by the subject during the trial epoch (ten seconds).

Because of the responsiveness of the EEG measures, special care was taken to reduce perceptual distractions. To this end, the lighting in the laboratory was kept at a low intensity and care was taken to prevent extraneous noise (i.e., no squeaking chairs, no pencil tapping). The soundproof nature of the lab aided in this regard.

D. Hypotheses

Our general expectation for the manipulation conditions is that social loading will increase relative right-brain activity. In the selected experimental setting, the elements of social loading are: (1) the equal competency manipulation of the subject vis-à-vis his/her partner and in comparison to a "national standard," (2) working as a partner in the second phase (team setting) after the manipulation is performed, (3) information feedback from the partner in arriving at a final decision about the slide, and (4) partner agreement or disagreement with the subject's initial choice. If an actor is manipulated into an equal high status state (believing that both he/she and his/her partner possess high ability in the task), we expect the actor will process information while in that state in a more right-hemispheric (holistic) cognitive mode.

If social loading does increase right-brain contribution to hemispheric balance, we would expect the following hypotheses to be supported in our experimental setting:

1) Using subjects as their own control, in the team phase (Phase II) of the experimental condition, we expect a relative increase in right-brain activity compared with the premanipulation phase (Phase I) of the experimental condition.

2) After partner feedback in the team phase (Phase II) of the manipulation condition, we expect a relative increase in right-brain activity. In other words, we expect more right-brain activity on final than on initial choices after the manipulation.

3) We expect the right hemisphere to make a greater contribution to total mental activity in experimental than in control conditions in Phase II.

4) In addition, we tested the hypothesis that the right hemisphere would make a greater contribution to total mental activity in final decisions on disagreement trials than on agreement trials.

E. Experimental Procedure

This section describes the procedures of the separate experimental studies conducted in the sequence in which they were run with a discussion of the procedural refinements made at various stages. We describe in detail the first stage, noting alterations in procedure for the second and third stages.

1. Stage One: Male Experimental Condition

In this first experimental condition, eight right-handed male college undergraduates acted as subjects. Upon arriving at the laboratory, an experimenter (E_1) escorted subjects to an interview room where the purpose of the experiment was explained.

Subjects were told they were participating in a two-part study. In the first part, an ability test was to be administered which the subject would complete individually. For the second part, the subject would be working with a partner as a team member on a similar ability test. The "partner" was actually an experimental confederate. Subjects were led to believe that performance in the team situation, the second part of the study, would require the use of the ability tested in the individual situation of the first part, thereby encouraging them to do as well as possible in the first part.

It was explained that the test was designed to measure an individual ability, called Spatial Judgment ability. This ability represents an individual's competence at estimating distances within the context of a picture of a natural setting. It was further explained that the combined score of individuals working as a team are typically higher than the combined scores of individuals working separately.

Subjects were further told that the purpose of the study was to see what types of brain activity accompany the taking of the test, both while working individually and as a team member. Thus, a monitoring of brain activity would be made while the tests were taken. Subject consent to participate was then obtained.

The three Grass gold-cup electrodes were then attached to the scalp of the subject, as described in section IIC, Equipment. Subjects were then escorted to an equipment room containing a slide screen and polygraph, and were greeted by a second experimenter (E_2). Each subject was seated at a table next to a "partner" (the confederate) with a curtain between them, blocking their view of one another. E_2 sat directly in front of the subject and "partner," at a distance of about six feet.

Three feet above E_2's head was a 20" x 24" rear projection screen for presentation of slides. Electrodes of both participants were connected to the circuit board of the EEG.

E_2 then restated the general purpose of the study before giving the specific details of the test. Subjects were told that the Spatial Judgment test had been administered to many college students throughout the country, and that national standards had been established. By these national standards, a score of 7-10 correct answers was considered "superior," 4-6 was considered "average," and 0-4 considered "below average."

The test in the study's first part was to consist of a series of ten slides, each showing a picturesque scene of Europe in black and white. Superimposed on the scene would be a single white line in a vertical or horizontal position. Subjects were to decide whether the line in the picture was greater or less than some specified distance announced by E_2. The procedure for viewing each slide was as follows: the subject viewed the slide for a ten-second period (epoch) while a monitoring was made of his alpha activity. The subject was instructed not to blink while viewing the slide so that eye movement artifacts to the EEG recordings would be minimized. He then recorded an initial answer by pressing a button on a control panel in front of him on the desk. After his initial choice had been made, the same slide was shown a second time for ten seconds, and again a measure of alpha activity was taken. He then recorded his final answer by pressing a second button on the control panel. Only the final choice was believed by the subject to count toward his score. After the final choice, the control panels were cleared by E_1, who operated a master control panel from another room. After an initial practice slide, this same procedure was repeated for each of the ten slides comprising the test.

A third experimenter (E_3) sat in the equipment room at a table containing the analog to digital converter, out of view of the subject. E_3 hand-recorded the amount of alpha activity occurring in each hemisphere of the brain of the subject for each ten-second epoch.

After the first "test" was completed, E_1 entered the equipment room with a score sheet containing the number of "correct" answers to the test. It was publicly announced that the subject had scored nine of ten correct answers and his "partner" had scored eight of ten correct, placing both participants in the "superior" category on the "national standards" for the test. This manipulation was designed to have the subject believe that he and his partner were of equal ability.

E_2 then explained the second part of the study, during which the subject would be working with his "partner" (the confederate) in a team situation. In the team situation, each participant would view 25 slides similar to those of the first part of the study, the individual test. The team score was to be the combined number of final correct answers made by the participants working together. The subject was reminded that this score was typically higher than the combined scores of individuals working alone. Next was shown the "national standards" for team performance: 37-40 was "superior," 32-36 was "average," and below 32 was "below average."

The procedure began as in the first part, with a viewing of the slide for a ten-second period (epoch) while a monitoring was made of the alpha activity. And again, the subject recorded his initial choice by pressing a button on the control panel in front of him on the desk. A light on the control panel then informed the subject of his "partner's" initial choice. All communication between subject and "partner" was through the control panel, which was activated by E_1 from the master panel in another room.

It was emphasized that the objective of the test was to obtain a high team score and that, because of this, the subject should carefully consider his "partner's" initial choice before making a final decision about the slide. Twenty of 25 trials were controlled to show disagreement on initial choice between the participants; five trials showed agreement.

Each slide was then viewed a second time for ten seconds, while again a monitoring was made of the EEG. And finally, the subject recorded his final choice by pressing another button on his control panel. After an initial practice slide, this same procedure was followed for each of the "test's" 25 trials.

After completing the Spatial Judgment "test" of the team situation, subjects completed a questionnaire designed to determine if the manipulation had been successful. Subjects were then returned to the interview room, where electrodes were removed. They were further interviewed to determine if the manipulation was successful, then debriefed, paid an honorarium of $5.00 and dismissed.

2. Stage II: Male Control Condition (No Manipulation)

Encouraged by the general results of the first experimental study, which are reported in the data section, we nevertheless saw the need to rule out factors that may have contributed to the effects we observed and to refine the elements of our experimental procedures.

As discussed later, a right shift was observed in the study just described. We were concerned that an habituation-fatigue factor may have influenced our results. It may have been a consequence of the subject's becoming habituated to the setting and becoming accustomed to the sequence of events rather than responding to the social loading elements of the

manipulation. As a subset of this concern, we questioned whether the shift of lateralization toward the right in the final decision of Phase II was due to ordering effects, including habituation. We also wondered if the acts of making an initial and then final decision were determining our results rather than the presence of social loading.

We therefore decided to establish a lateralization baseline wherein none of the social manipulations were present and one in which ordering effects could be accounted for. Therefore, we ran twenty right-handed male subjects in the same experimental setting, but with no manipulation and with no partner feedback.

In addition, we made the following modifications in our experimental procedures: (1) We equalized the number of Spatial Judgment slides presented to the subjects in each of the two phases of the experiment. For each phase, twenty slides were presented. (2) From the available Spatial Judgment slides, we selected the forty which most closely approached the .5 probability of subject choice. (3) Additional equipment acquisition permitted us to run two subjects simultaneously, obviating the need for a confederate. And (4) subject responses to the stimulus slides ("greater" or "less" than) were recorded by an experimenter in both Phase I and Phase II.

For the first experimental study, we had assumed that each slide in the Spatial Judgment series approximated .5 probability of choice. We subsequently discovered that several of the slides in the series deviated from .5 to an unacceptable extent, and were viewed as veridical by subjects. We then selected the forty slides that deviated least from criterion. Our choice was made from a slide-by-slide probability record created by Ruth Cronkite, who initially pretested and standardized this task.

Although we were concerned with the potential ordering effects, we felt they had not, in fact, accounted for our results in Stage One. Thus, for the present study, we anticipated no ordering effects, and predicted no significant differences in lateralization between Phase I and Phase II nor between the first and second choices in Phase II. Although we set out to test this specific hypothesis, our more general concern was to establish a baseline for comparison with further studies in which elements of the manipulation were varied.

General procedure for this study, then, was essentially the same as that for the first study, with these modifications. In contrast with the first study, here subjects were not compared to a national standard, not led to believe they would be working with a partner, nor was feedback given. Since this study has no manipulation, at the point in the procedure where a manipulation would normally occur, none was given and, instead, the subjects were allowed a few minutes' rest period. Also, twenty slides were presented in each phase of the experiment.

3. Stage Three: Female Experimental and Control Conditions

We wanted a replication of the above studies with appropriately randomized conditions and with randomization of such potentially influencing factors as the room in which electrodes were attached, seating with respect to polygraph, and the room in which wiring was being done. Because of availability of subjects, we replicated using right-handed female subjects. We anticipated no sex difference with respect to our general hypothesis.

For this study, we ran two separate conditions. The first of these was a replication of the Stage One study, which involved the high-self,

high-partner competence manipulation, and partner feedback with subjects working as a team in the second phase. The second of these was a baseline condition with no status manipulation, no feedback, no partner, in replication of the Stage Two research. Both of these were conducted with the improved laboratory procedures of Stage Two; i.e., an equal number of slides (twenty) in each phase (chosen to approach the 0.5 probability of subject choice) and two subjects instead of the use of a confederate.

Importantly, appropriate randomization procedures were observed. Subjects were randomly assigned to the two conditions. Subjects were randomly assigned to the preparation rooms, where electrode placement and initial introduction to the study took place. Experimental assistants were randomly assigned to the preparation room. Further, subjects were randomly assigned to the seats in the experimental room.

Second, several steps were taken to improve on the credibility of the manipulation. In addition to public announcement (by host experimenter), each subject was shown a score sheet showing the "correct" and "incorrect" answers obtained by subject and partner. The announced score of subject and partner were the same, so that there was no basis for believing they were of unequal ability. However, to further insure credibility, the score sheets shown the subjects, while indicating the same score, were different with respect to the specific "correct" and "incorrect" answers.

Finally, the national standards scores were adjusted to be several points higher than the sum of the individual scores assigned to subjects. This was done to strengthen the assertion that team scores were typically higher than the combined individual scores.

The hypothesis of this study was essentially the same as that of the first study, except that here we were in a position to make the desired

comparisons in the context of a single design. Further, we have introduced procedural refinements, credibility of the manipulation is greater, and randomization permits use to use more powerful statistical models for analysis.

F. Overview of Sequence of Studies

As noted, in pretests we demonstrated that we in fact could measure laterality in our lab, with results comparable to those reported in the literature. On the basis of pretests, we selected a task and an experimental setting. We then began a series of experimental investigations in order to test our hypotheses. We report here on the first three stages of this investigation. First (in Stage One), we ran a small group of right-handed males who were manipulated into equal high competence states after the series of individually performed trials to determine if, indeed, the postulated phenomenon occurred and was detectable. We then conducted a study with right-handed males in the paradigm used previously, omitting all elements of the manipulation (Stage Two). We were particularly concerned with having this data, in order to assess ordering and habituation effects. Finally (in Stage Three), we replicated the control and experimental condition of the first two stages, making use of appropriate randomization procedures with regard to variables such as condition assignment, seating of subjects, room in which electrodes were attached. We used right-handed female subjects for the two conditions comprising the replication.

For a schematic summary of the experimental conditions, see Figure 1a. Figure 1b schematically depicts the derivation of measurements for each decision epoch.

Figure 1a

Overview of Conditions in the Three Research Stages

Stage	Condition	Phase I	Manipulation	Phase II
Stage I	Male Experimental N = 8	Ten Trials Initial and Final decisions (T1 and T2) Subject works alone	Subject and Partner both told they scored very high on task ability.	Twenty-five Trials Initial and Final decisions (T3 and T4) Team situation: exchange of opinions before final decision. 80% Disagreements
Stage II	Male Control N = 20	Twenty Trials Initial and Final decisions (T1 and T2) Subject works alone	None	Twenty Trials Initial and Final decisions (T3 and T4) Subject works alone
Stage III (Experimental and Control Conditions Randomized)	Female Experimental N = 12	Twenty Trials Initial and Final decisions (T1 and T2) Subject works alone	Subject and Partner both told they scored very high on task ability.	Twenty Trials Initial and Final decisions (T3 and T4) Team situation: exchange of opinions before final decision. 80% Disagreements
	Female Control N = 16	Twenty Trials Initial and Final decisions (T1 and T2) Subject works alone	None	Twenty Trials Initial and Final decisions (T3 and T4) Subject works alone

Figure 1b

Schematic Representation of Derivation of Dependent Variables

Measures of alpha from the right and left hemispheres are taken for each decision and on each trial in each of the two phases. These measures are used to construct two dependent variables for each of the four decision epochs, 1) total alpha activity, and 2) the lateralization index, for each person. Each individual therefore has four scores by which he or she is characterized. Aggregation across persons permits each condition to be characterized in a similar manner. The schematic shows how each dependent variable is constructed for the n trials in decision epoch Ti.

Ti Decision Epoch

Left Hemisphere Alpha Activity

Right Hemisphere Alpha Activity

(LH + RH) = Total Alpha

$$\frac{LH - RH}{LH + RH}(100) = \text{Lateralization Index}$$

Positive Laterality Index (more left hemisphere alpha activity) indicates more right hemisphere involvement.

Negative Laterality Index (more right hemisphere alpha activity) indicates more left hemisphere involvement.

III. ANALYSIS OF TOTAL ALPHA AS AN INDICATOR OF MENTAL EFFORT OR TASK INVOLVEMENT

Alpha production has been taken, conventionally, to index the brain at rest. For a measure of total alpha, the scores recorded for each hemisphere were added together. Our recordings permit us to assess alpha across the phases and decisions of our design, and to differentiate between agreement and disagreement trials.

We are thereby able to use alpha production to assess relative mental effort required by the initial and final decisions, the two phases, and agreements and disagreements within a condition. Clearly, we can compare the ordinal characteristics of alpha production across conditions. We have used t tests for statistical analysis. While t tests are inappropriate where repeated measures are involved, the procedure seems warranted due to the exploratory nature of the investigation and the small number of subjects in some analyses. We adopt a significance level of .10 so as to maximize our ability to detect differences. In general, our strategy was to maximize the possibility of finding patterns in the data which will inform future research.

In the total alpha analysis, we first calculate an average total alpha output for each individual in each decision epoch. This is done by adding together for each individual the right hemisphere alpha and the left hemisphere alpha scores for each trial and then taking an average over the total number of trials. Individual averages are then averaged in each decision epoch over all subjects in a particular condition to arrive at an average alpha activity score for each decision epoch in a given condition. This is the data which is analyzed. We look for changes in average alpha activity across decision epochs and between agreement and disagreement trials.

Analysis of total alpha activity is focused on changes in the quantity of alpha across decision epochs. Phase I of the experimental setting consists of two decision epochs, an initial choice on each slide (t1), and a final choice on each slide (t2). Phase II also consists of two decision epochs, an initial choice (t3) and a final choice (t4) for each slide.

Alpha activity is taken as an inverse measure of mental effort: the more alpha the less effort. The less alpha the more effort. This interpretation is consistent with that of the accumulated findings in the physiological literature.

A. Stage One: Male Experimental Condition

1. Data

Figure 2 graphs data for total alpha scores averaged over the eight subjects in the Male Experimental condition by decision epoch. There is a significant increase in total alpha output from t1 to t2. There is no significant change in total alpha output from t2 to t3 for either agreement or disagreement trials. There is a significant increase in alpha output from t3 to t4 for both agreement and disagreement trials. Statistical tests are summarized in Figure 3.

Looking now at differences between decisions across phases, we find a significant increase in total alpha from initial choice in Phase I to initial choice in Phase II, and similarly a significant increase in total alpha from final choice, Phase I, to final choice, Phase II, for both agreement and disagreement trials. Finally, we note that there is a significant difference between agree and disagree trials at t4.

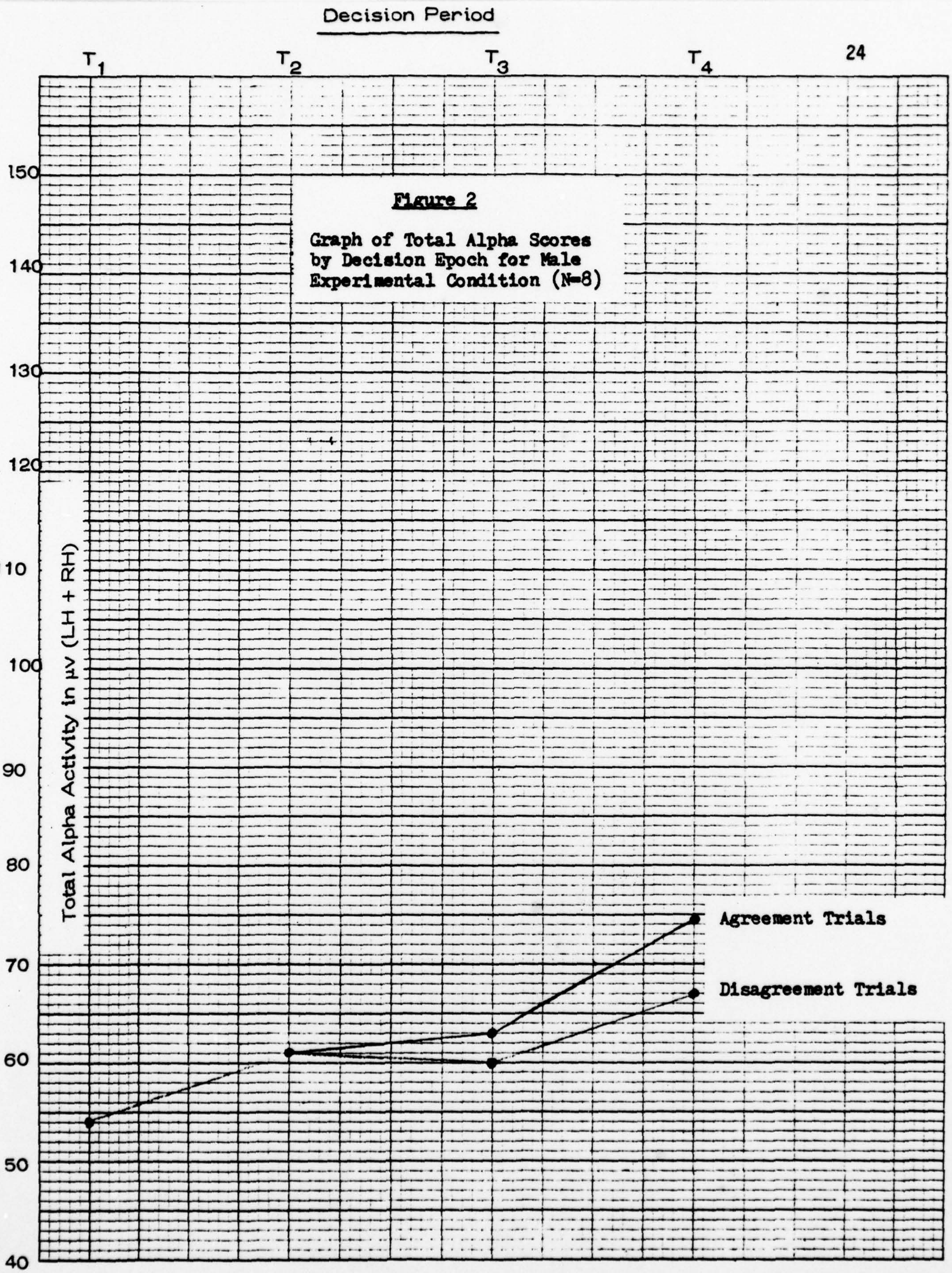


Figure 2

Graph of Total Alpha Scores by Decision Epoch for Male Experimental Condition (N=8)

Figure 3

One-tailed t-Tests on Differences in Total Alpha Output Across Decision Epochs for Male Experimental Condition (N=8)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	2.32	7	.05
t2 vs. t3 (Disagreements)	-	7	n.s.
t2 vs. t3 (Agreements)	-	7	n.s.
t3 vs. t4 (Disagreements)	3.04	7	.01
t3 vs. t4 (Agreements)	1.66	7	.10
Between phases:			
t1 vs. t3 (Disagreements)	1.70	7	.10
t1 vs. t3 (Agreements)	3.15	7	.01
t2 vs. t4 (Disagreements)	2.11	7	.05
t2 vs. t4 (Agreements)	2.06	7	.05
Agreements vs. Disagreements at t4	1.83	7	.10

2. Interpretation

Taking alpha level as an inverse measure of mental effort in the situation (Hardt and Kamiya, 1978), we have an indicator of changes in subject's relative effort throughout different parts of this study. The data is consistent with the following assertions:

1. Final choices in either phase are less involving (produce more alpha) than initial choices.
2. Choices in Phase II are less involving (produce more alpha) than the corresponding choices in Phase I.
3. Final decisions on agreement trials are less involving (produce more alpha) than final decisions on disagreement trials.

Increased alpha production seems to be associated with a) familiarity with the task in general (Phase I/Phase II comparison), b) opportunity to confirm initial judgments (Initial/Final decision comparison), and c) social support from the partner (agree/disagree comparison).

B. Stage Two: Male Control (No Manipulation)

1. Data

Figure 4 graphs data for total alpha scores averaged over the twenty subjects in the Male Control condition by decision epoch. It also displays total alpha scores for the Male Experimental condition for comparison purposes. The same pattern of results is found in this condition as in that of the Male Experimental group. There is a significant increase from t1 to t2 and from t3 to t4. Across phases, there is an increase (not significant) from t1 to t3, and a significant increase from t2 to t4. Statistical tests are summarized in Figure 5.

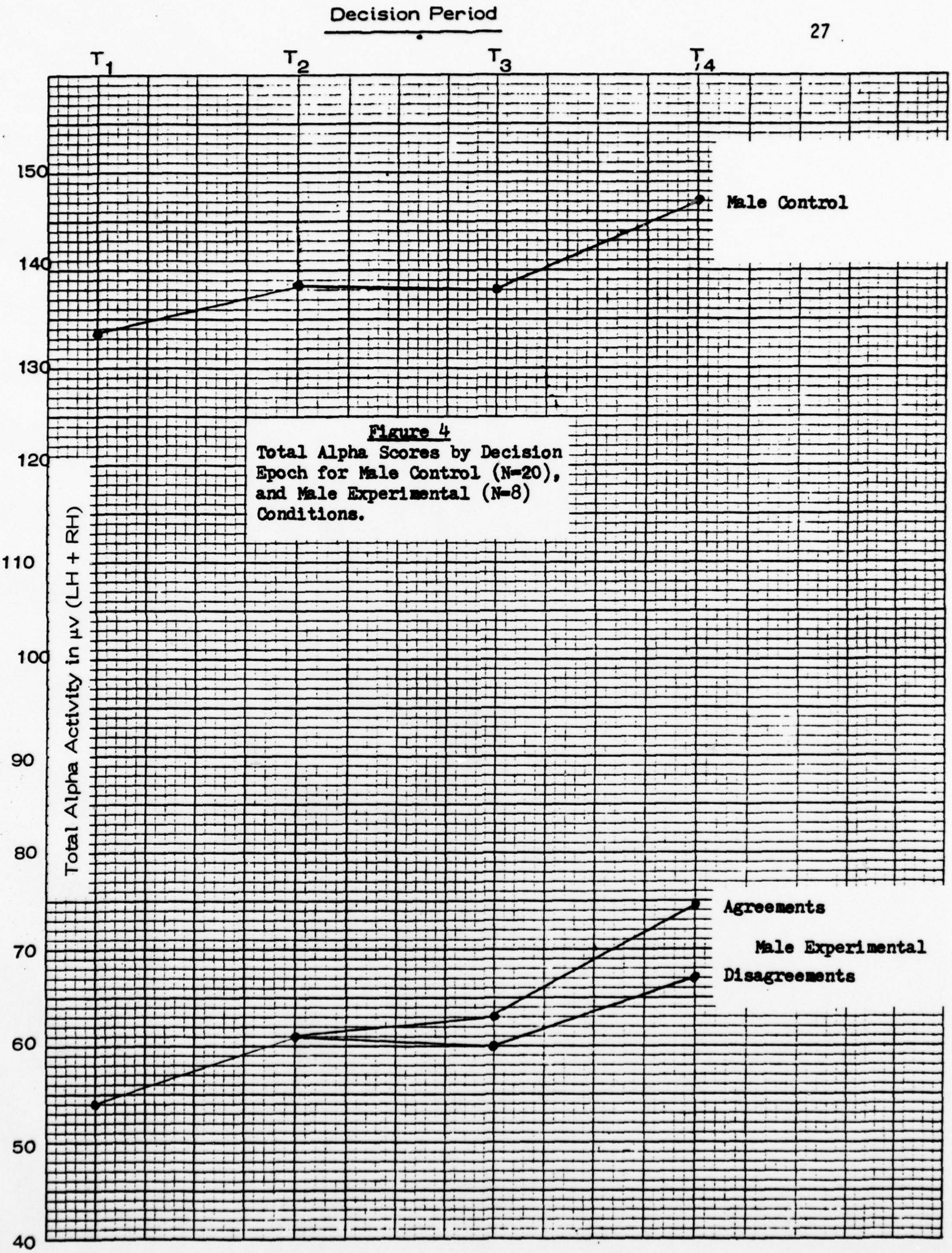


Figure 4
Total Alpha Scores by Decision Epoch for Male Control (N=20), and Male Experimental (N=8) Conditions.

Figure 5

One-tailed t-Tests on Differences in Total Alpha Output Across Decision Epochs for Male Control Condition (N=20)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	1.79	19	.05
t2 vs. t3	-	19	n.s.
t3 vs. t4	2.56	19	.01
Between phases:			
t1 vs. t3	-	19	n.s.
t2 vs. t4	1.35	19	.10

2. Interpretation

The data is consistent with the previous interpretation that final choices require less mental effort than initial choices, and that Phase II requires less mental effort than Phase I. We conclude that the effect of decision epochs on mental effort is the same for the Male Experimental and Male Control conditions.

C. Comparison of First and Second Stages

Measurements of total alpha in the Male Experimental and Control conditions tell a consistent story. Alpha output is higher on final decisions than on initial decisions in both phases for both conditions. We interpret this as indicating that there is less involvement associated with making the final decision, after having already come to a tentative decision on the same problem. Initial and final decisions in Phase II are higher in alpha than the corresponding decisions in Phase II for both Experimental and Control conditions. We assume that this is also due to reduced mental effort in Phase II compared with Phase I because the task is a repeat of the Phase I task. In the Experimental condition, final decisions on agreement trials show more alpha than final decisions on disagreement trials. This is consistent with the notion that there is more involvement on disagreement trials. (See Figure 12, page 44.)

Finally, alpha output is substantially higher for Controls across all decision epochs than for Experimentals. In the Experimental setting, subjects were told at the beginning of the study that they would be working with a partner and that comparative scores would be reported for both subjects. This apparently created a significant increase in involvement for the Experimental subjects compared with the Control subjects for whom no

mention of comparative scores or partner was made. We take this particular difference as suggestive only, due to equipment and calibration variation between the studies.

D. Stage Three: Female Experimental and Control Conditions

In this study, females were employed as subjects in contrast to the males of the previous studies. In addition, both Experimental and Control groups were run on a randomized basis. This study employed appropriate randomization and procedural protocols. Information gathered from the first two studies were used to make changes which we felt added to either the analysis or measurement, or smooth running of the experimental setting. In analysis of this study, we use the same format as in the previous studies.

1. Data

Figure 6 graphs data for total alpha scores averaged over the sixteen subjects in the Control (no competence manipulation, no partner, no feedback) condition for each decision epoch. Statistical analysis (Figure 7) indicates that there is a statistically significant increase in total alpha output from t1 to t2 and from t3 to t4, but not from t2 to t3. Across phases, there is a less significant increase from t1 to t3 and from t2 to t4.

Figure 6 also graphs total alpha data for the Experimental subjects, by decision epoch and agree-disagree trials in Phase II. Statistical analysis (Figure 8) indicates that there is a significant increase in total alpha output from t1 to t2 and from t3 to t4. There is also a significant decrease in total alpha from t2 to t3. These findings hold for

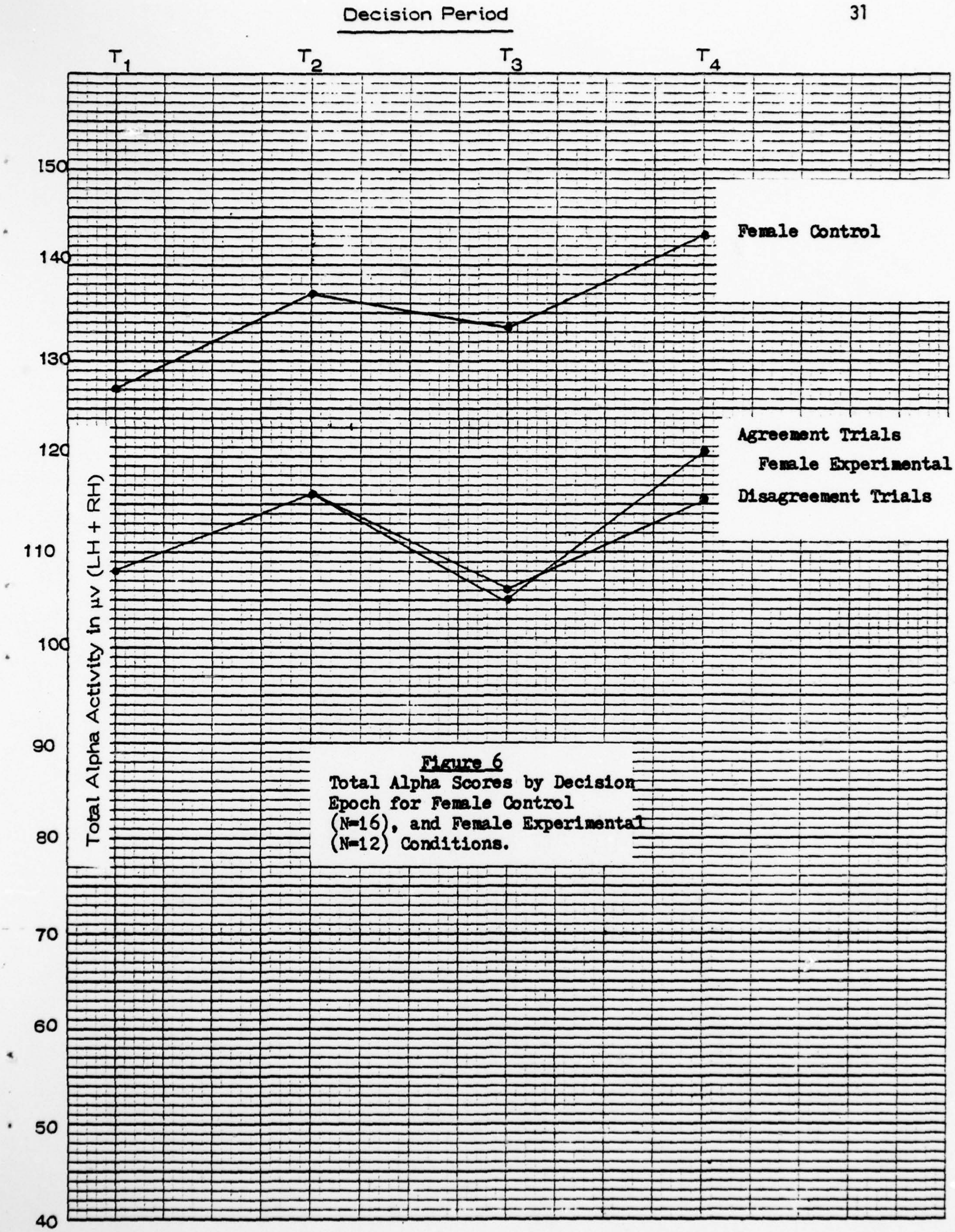


Figure 6
Total Alpha Scores by Decision Epoch for Female Control (N=16), and Female Experimental (N=12) Conditions.

Figure 7

One-tailed t-Tests for Differences in Total Alpha Output Across Decision Epochs for Female Control Condition (N=16)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	3.24	15	.005
t2 vs. t3	-	15	n.s.
t3 vs. t4	4.01	15	.005
Between phases:			
t1 vs. t3	1.52	15	.10
t2 vs. t4	1.60	15	.10

Figure 8

One-tailed t-Tests for Differences in Total Alpha Output Across Decision Epochs for Female Experimental Condition (N=12)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	3.73	11	.005
t2 vs. t3 (Disagreements)	1.47	11	.10
t2 vs. t3 (Agreements)	1.62	11	.10
t3 vs. t4 (Disagreements)	3.82	11	.005
t3 vs. t4 (Agreements)	2.89	11	.01
Between phases:			
t1 vs. t3 (Disagreements)	1.48	11	.10
t1 vs. t3 (Agreements)	-	11	n.s.
t2 vs. t4 (Disagreements)	-	11	n.s.
t2 vs. t4 (Agreements)	-	11	n.s.
Agreements vs. Disagreements at t4	-	11	n.s.

both agreement and disagreement trials. Across phases, the only significant comparison is t1 to t3 for disagreement trials.

We find no significant differences between Experimental and Control groups for Phase I initial or final decisions. For Phase II, all comparisons between Experimentals and Controls are significant; both initial and final decisions, and agree/disagree trials (see Figure 9).

2. <u>Interpretation</u>

Our assumption concerning total alpha output is that more alpha represents less mental effort for the individual in the situation. On the basis of the male groups (Stages One and Two), we expected that there should be less involvement on final decisions than on initial decisions, less involvement in Phase II than in Phase I, less involvement on agreement than on disagreement trials, and less involvement in Control than in Experimental groups. Thus, we should find increased alpha on final relative to initial decisions. This is supported by the data for both phases of the Control group and for both phases of the Experimental group on both agree and disagree trials. There is no inconsistent evidence.

With regard to phase differences, we find higher alpha in Phase II for Controls than in Phase I. This conforms to the pattern. For the Experimental group, however, we do not find differences between Phase I and Phase II. Is this inconsistent? We think not. We have argued that the involvement associated with the task should decrease in Phase II relative to Phase I. However, in the Experimental condition, Phase II has the added component of working with a partner, a partner who, although as good as you are, nevertheless disagrees with you most of the time. Apparently this source of involvement keeps the Phase II alpha output at

Figure 9

One-tailed t-Tests for Differences in Total Alpha Output
Between Female Control (N=16) and Female Experimental (N=12) Conditions
By Decision Epochs

Comparison	t Value	df	Significance Level
t1	-	26	n.s.
t2	-	26	n.s.
t3 (Disagreements)	1.807	26	.05
t3 (Agreements)	1.900	26	.05
t4 (Disagreements)	1.73	26	.05
t4 (Agreements)	1.40	26	.10

the same level as the Phase I output in the Experimental condition for these female subjects.

With regard to the agree/disagree comparison in the Experimental condition, the t-test is not significant at the .10 level. (Experimental t-value = 1.31, t-value for significance at .10 level = 1.36.) The mean of the agree trials at t4 is above the mean of the disagree trials at t4, however, so the data does order in the expected direction.

With regard to the comparison between conditions, we find that in all decision epochs the means for the Experimental group are below those for the Control group. Statistical tests for differences between the groups at each decision point indicate no significant differences for decisions 1 and 2 (Phase I), but do indicate significant differences between initial and final decisions between the Control and Experimental groups on both agree and disagree trials. This is consistent with our expectation if we assume that for the Experimental subjects in Phase I the anticipation of working with a partner in Phase II produced a slight increase in involvement, thus measurably lowering the alpha output, but not to a statistically significant degree. In Phase II, actually working with a partner and receiving feedback from her about the correct answer should be a stronger involvement creater, and in fact a significantly lowered alpha output is demonstrated.

Under the assumption that total alpha activity is an inverse measure of involvement in the situation, the following conclusions and interpretations can be made:

1. In both the Experimental and Control conditions, initial choices showed less alpha activity than final choices, both in Phase I and Phase II, and for both agreement and disagreement trials in

Phase II. This is consistent with the notion that final decisions on a problem already viewed are less involving than initial decisions on a novel problem.

2. In the Control condition, Phase II choices are higher in alpha activity than the corresponding Phase I choices, but in the Experimental condition they are not. This is consistent with the notion that involvement is lower in Phase II Control than in Phase II Experimental because the subject has already performed one series of problems and the second presents no new difficulties, whereas in the Experimental condition involvement is not lowered because of the social factors introduced by the competence assessment and by a partner with whom the subject frequently disagrees. Further, Experimental and Control groups are not significantly different on Phase I measures but are significantly different on Phase II measures.

3. In the Experimental condition, the t4 alpha activity on agreement trials is higher, but not statistically significant, than on the disagreement trials. This is consistent with the idea that agreement trials are less involving than disagreement ones. Social support provided by agreement from the partner apparently lessens task involvement. Disagreement trials are based on fifteen trials per subject, while the agreement trials are based on only four trials per subject. (A later study presents an equal number of agreement and disagreement trials.)

E. Summary of Total Alpha Analysis for the Three Stages

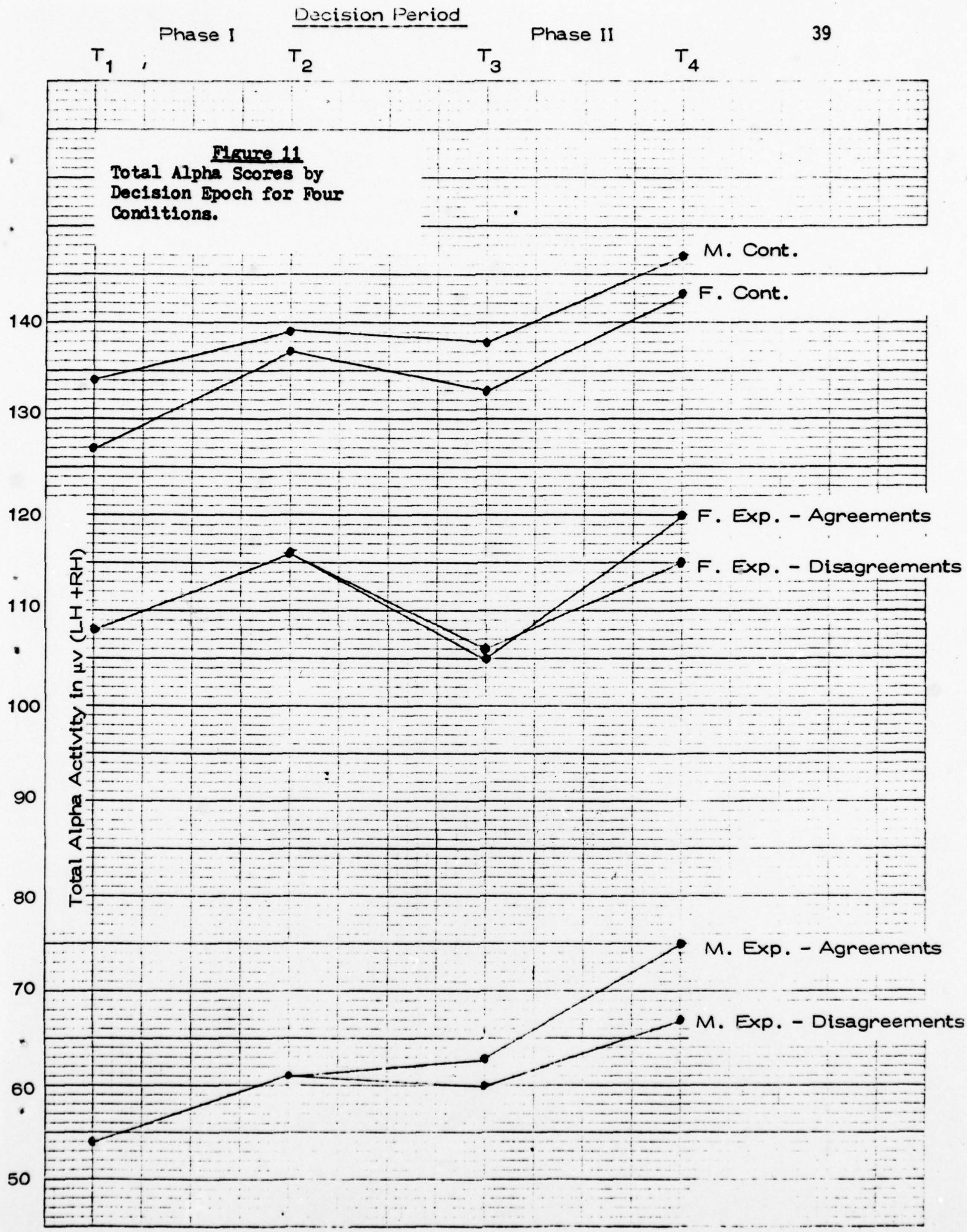
For the Male Experimental, Male Control and the randomized Female Experimental and Control groups, right and left hemisphere alpha measurements were added together to obtain a measure of total alpha for each subject in each of the four decision periods. Figure 10 presents mean alpha scores for each condition by decision period. Figure 11 displays this data graphically.

Figure 10

Mean Alpha Scores (RH + LH) by Condition and Decision Period for Four Conditions. (Standard deviation is given in parentheses)

Decision Period

Condition	Phase I T1	Phase I T2	Phase II T3	Phase II T4	
Female Control N = 16	127.26 (37.04)	136.93 (38.27)	133.48 (42.91)	142.90 (42.49)	No Feedback
Female Experimental N = 12	108.02 (40.33)	116.05 (46.71)	106.03 (34.86)	115.36 (40.16)	Disagreements
			105.15 (32.94)	120.35 (41.70)	Agreements
Male Control N = 20	133.56 (52.59)	138.72 (55.54)	137.93 (59.74)	147.36 (60.41)	No Feedback
Male Experimental N = 8	53.84 (27.96)	60.80 (32.61)	59.82 (34.12)	66.90 (39.64)	Disagreements
			62.85 (32.57)	74.55 (47.19)	Agreements


Decision Period
Phase I
Phase II
T1
T2
T3
T4
Figure 11
Total Alpha Scores by
Decision Epoch for Four
Conditions.
M. Cont.
F. Cont.
F. Exp. - Agreements
F. Exp. - Disagreements
M. Exp. - Agreements
M. Exp. - Disagreements
Total Alpha Activity in μv (LH +RH)
140
130
120
110
100
90
80
70
60
50

The following observations can be made:

1. In all cases there is an increase in alpha activity from initial choice to final decision (t1-t2 and t3-t4 in both phases in all conditions).

2. Levels of alpha activity in all four decision epochs is markedly lower in Experimental conditions than in Control conditions.

3. In both Experimental conditions (Male and Female), the Phase II increase in alpha from initial (t3) to final choice (t4) is greater on agreement trials than on disagreement trials.

4. In both Experimental conditions (Male and Female), the Phase II alpha level on t4, final decision, after an agreement trial is greater than final decision after a disagreement trial.

5. Males and females show no significant differences in Control conditions. (Comparisons of males and females across the Experimental conditions is not possible due to equipment calibrations used.)

6. Initial and final choices in Phase II are characterized by higher levels of alpha activity than the corresponding choices in Phase I, except in the Female Experimental condition wherein both Phase II alpha levels are lower than the corresponding Phase I levels. In this respect the males may be interpreted as reacting differently to the experimental situation than the females.

These observations are amenable to a consistent interpretation across conditions and decision periods. Since alpha activity has been associated with relaxation and being at ease, we interpret higher alpha activity in this experimental situation as indicative of a greater degree of comfort and less mental effort in the situation. Under this interpretation, we see that subjects in all conditions were more at ease in Phase II than in Phase I with the exception of the Female Experimental condition (we return to this condition in a moment). In Phase II, whether the subject is

working alone (Control condition) or with a partner (Experimental condition), the task is no longer novel and hence relaxation should be increased. In the Experimental condition, the subject has been told that he or she is very competent on the task, which could facilitate relaxation in the second phase. Indeed, for the Male Experimental condition, alpha levels are higher in Phase II initial and final choice than they were in Phase I, and in addition, the increase over Phase I levels is greater in the Experimental condition than it is for the Control condition. However, the Female Experimental condition presents a different picture, which we will discuss momentarily.

Our interpretation of alpha activity also makes sense of the differences found between Control conditions and Experimental conditions. In the Experimental conditions, the anticipation of working with a partner (present in Phase I) and the actual presence of an 80% disagreeing partner—discrepant with the manipulation of high competence—(present in Phase II) should serve to increase involvement or focus in the situation. This, in turn, would serve to lower alpha activity in the Experimental conditions, exactly as observed.

In the Experimental conditions, disagreement with the partner should serve to heighten involvement and hence to lower alpha activity levels, while agreement with the partner should lessen involvement and raise alpha levels. This is exactly what is observed in both males and females. Not only is alpha output higher on final decision after agreement from the partner than on final decision after disagreement from the partner but, furthermore, the increase in alpha level from initial to final choice is greater on agreement trials than on disagreement trials. This holds true for both male and female subjects in the Experimental condition.

Female Experimental subjects show lower Phase II alpha levels relative to Phase I levels. On the assumption that subjects are more at ease with the task in Phase II because it is no longer novel, we argued that alpha levels should increase. This expectation is upheld in the Male Experimental condition, but not in the Female Experimental condition. Information which may be pertinent to the resolution of this difference was obtained in post-experimental interviews. Female subjects frequently reported (and male subjects did not) that they just didn't think they were very good at judging distances. If this feeling was prevalent among the female subjects, they may not have been more at ease with the task in Phase II than they were in Phase I. This would account for the lower alpha activity for Female Experimental subjects in Phase II relative to Phase I. Unfortunately, the post-experimental questionnaire was not designed to systematically gather data on this unexpected event. Thus, we have no reliable means of directly assessing this interpretation. We do, however, have at least an indirect means. If it is true that female subjects were less at ease in Phase II due to lower perceived competence on the task, then this should be reflected in a comparison of the Male and Female Control conditions. We might expect that males would show greater increases in alpha activity in Phase II relative to Phase I than females. This is true for the final decisions but not for the initial choices. One more piece of relevant data should be pointed out. The pattern of lower alpha activity for Female Experimental subjects is reversed in the final decision on agreement trials. Agreement trials for Male and Female Experimentals increases alpha activity. It may be that this information (agreement from the partner) is strong enough to override the subject's self-conception of her ability on the distance-judging task.

We interpret these observations to be consistent with the assumption that changes in an individual's alpha output varies inversely with task involvement. We conclude that alpha level is affected by condition, phase, choice, and feedback from partner. We have suggested that there may be an interaction effect between sex of subject and the experimental manipulation. It appears that for males the presence of a partner who disagrees most of the time is not as great an involvement inducer as it is for the females. We believe total alpha to be a useful and reliable indicator of involvement in social comparison task-oriented situations.

Figure 12

t-Tests for Difference of Means on Total Alpha Measures Between Male Control and Male Experimental Conditions for Decision Epochs and Agree/Disagree Trials

Decision Epoch	t Value	df	Significance Level
1	4.035	26	.0005
2	3.696	26	.005
3 (Disagreements)	3.455	26	.005
3 (Agreements)	3.331	26	.005
4 (Disagreements)	3.460	26	.005
4 (Agreements)	3.045	26	.005

IV. AGGREGATE ANALYSIS OF THE LATERALIZATION INDEX FOR THE FOUR CONDITIONS

Our last section showed that total alpha activity varies in a patterned and reasonable way across conditions, between phases, between decision epochs, and between agreement and disagreement trials. In this section we continue to assume that alpha reflects brain at rest, and a further assumption is that a differential change in the amount of alpha in each hemisphere inversely reflects change in the differential contribution of the hemispheres which, in turn, reflects altered cognitive processing.

It should be remembered that our design has two phases, each with an initial and final decision made for a series of trials. Within experimental conditions, social loading is represented by a comparison of Phase I and Phase II, with Phase II being more heavily loaded than Phase I. Within Phase II, the initial and final decisions are compared under the assumption that the final decision represents more social loading due to partner feedback. Our hypothesis of shift to increased right hemispheric contribution under conditions of social loading requires that we look at relative contributions of the hemispheres across time periods which have different social loading elements but with task held constant.

For each person, for each decision on each trial in each phase, bilateral recordings of alpha (8-13hz) were taken from the occipital area. This data was rendered into an index of relative hemispheric contribution by calculating, for each decision on each trial, (L-R/L+R)100. The index has the virtue of compensating for shifting alpha production, takes into account a changing denominator, and is appropriate for questions asking about the relative contribution of the hemispheres. Neither total alpha nor difference scores do this.

The index was calculated for each trial, and averaged over the trials for each decision in each phase for each person. Thus, there are four scores of lateralization for each person, one for each decision or time period. The alpha index was averaged over persons to obtain a score for each of the four time periods (initial and final decisions in Phase I and Phase II) for each condition (Male Experimental, Male Control, Female Experimental, and Female Control). These four scores characterize the conditions and are the data analyzed in this section.

In the following, we first look at the means themselves by each condition and aggregated to include all conditions—all Controls and all Experimentals. We then compare, within conditions, the scores for the decision epochs to assess whether or not differences greater than chance occur when predicted, in the Experimental conditions of social loading. Subsequently, we examine the shifts which occurred between the initial and final decisions of each phase to determine if the movement was by chance and in the predicted direction. Finally, we present percentage of persons who demonstrated a shift to the right in the two phases by condition.

A. Means of Laterality Index by Condition

Figure 13 displays means, standard deviations, and standard errors of the lateralization index for initial and final decisions for both phases of each condition. For each condition there are four scores. The initial and final decisions are referred to as t1 and t2, respectively. The initial and final decisions within Phase II are referred to as t3 and t4, respectively.

Figure 13

Descriptive statistics for lateralization index, at each time epoch for all conditions.

Time Epoch	All E+C N=56	All E N=20	All C N=36	Male E N=8	Male C N=20	Female E N=12	Female C N=16
T1							
X	-.82	.59	-1.61	7.91	0.63	-4.29	-4.41
SD	9.6	11.9	8.2	12.9	8.8	8.6	6.8
SE	1.3	2.7	1.4	4.6	2.0	2.5	1.7
CV*	-11.71	20.17	-5.09	1.63	13.97	-2.00	-1.54
T2							
X	.78	1.28	-1.93	6.71	-.74	-2.34	-3.42
SD	8.2	9.3	7.4	9.9	8.1	7.2	6.5
SE	1.1	2.1	1.2	3.5	1.8	2.1	1.6
CV*	10.51	7.27	-3.83	1.48	-10.95	-3.08	-1.90
T3							
X	-1.13	.32	-1.94	7.87	-1.62	-4.72	-2.33
SD	9.3	11.9	7.5	10.6	7.9	10.1	7.3
SE	1.2	2.7	1.3	3	1.8	2.9	1.8
CV*	-8.23	37.19	-3.87	1.35	-4.88	-2.14	-3.13
T4							
X	-.97	1.56	-2.37	9.10	-2.00	-3.47	-2.84
SD	9.5	1.18	7.9	9.9	8.2	10.4	7.7
SE	1.3	2.6	1.3	3.5	1.8	3.0	1.9
CV*	-9.79	.76	-3.33	1.09	-4.10	-3.00	-2.71

*The coefficient of variation by condition reveals that the Male Experimental group has the smallest variance in three time epochs and the Male Control the largest in four. The smallest variance, relatively, is for All Experimentals at T4, the epoch with the heaviest social loading.

1. Data

Immediately obvious from inspection of Figure 13 is the quite large standard deviations and standard errors, suggesting great variability in both the population and the sample. We make use of this observation in subsequent analyses.

Also immediately obvious from inspection of the data is that some of the scores are negative and some positive. Remembering that the index is an inverse indicator of hemispheric activity such that a negative score represents more right hemispheric alpha and more left hemispheric activity, we find that All Experimental subjects, male and female taken together, show positive signs, while All Controls show negative signs, on each of the four decisions. At the most gross level of analysis, we find that the Controls are characterized in all time periods by left hemispheric activity and that the Experimentals are characterized by right hemispheric activity.

The question should be asked why the Experimentals should show a difference from Controls in the first phase as well as in the second phase of the experimental setting. We believe that the pre-session instructions of the Experimental groups introduced an anticipation of interaction with social others and the anticipation shows up as right hemispheric on this aggregate level. The Males show the same pattern between Experimentals and Controls except at the initial decision in Phase I, t1. All of the Females, however, for both Experimentals and Controls, show negative scores, indicating in the aggregate a greater contribution by left hemisphere.

It will be noted that the Female and Male Controls exhibit similar

signs, negative scores suggesting left brain activity. The exception is in t1, the initial decision in Phase I—the Male Controls started with a positive sign, indicating more activity in the right hemisphere, and in the subsequent decision periods exhibit negative signs, indicating more activity in the left hemisphere. The Male Experimental group is characterized in each time period by a positive sign, indicating that all decisions were performed with more right hemispheric contribution.

2. Interpretation

When All Experimentals and All Controls are examined, we find differences in sign which are in accord with the general conception of social loading eliciting greater contribution from the right hemisphere. However, it would appear that the Male and Female Experimentals have behaved differently in each of the time periods, with the Males showing right hemispheric activity in the Experimental condition, while the Females show left hemispheric activity in both Control and Experimental conditions in all decision times.

Because of the large standard deviations and standard errors, we anticipate that closer scrutiny is necessary to establish which factors other than social loading are influencing hemispheric balance. It is clear from just the aggregate means that sex of subject is a candidate and that individual differences may be operative.

B. Statistical Comparisons of the Means of the Laterality Index

In the preceding section we looked at the means, their distribution, and their signs. In this section we compare aggregate means to determine if differences between the time epochs of each condition occurred by

chance. Figure 14 presents the results of paired t tests, two-tailed, giving the probability that differences on the lateralization index between decision epochs occurred by chance. The lateralization indices, entered on a trial-by-trial basis, are the data on which the statistical test is performed. In addition to the t value and associated probability, the figure indicates the direction of movement in the comparisons. A square around the probability indicates that the comparison showed movement toward increased right hemispheric contribution, and a circle indicates movement within the comparison to the left, regardless of the probabilities associated with the differences.

1. Data

We find, not surprisingly, that when all conditions are combined (N = 56), there is every suggestion that differences occur by chance. Similarly, looking at All Controls combined (N = 36), regardless of sex of subject, we find no probabilities that suggest differences which occur are due to factors other than chance. Comparing All Experimentals (N = 20), we find that the difference which is statistically significant occurs in the comparison of the Phase II initial (t3) and final (t4) decisions ($t = -2.64$, $p = .016$). As predicted under conditions of increased social loading, the hemispheric movement is toward the right hemisphere.

Thus far we have looked at twelve t-test results. Only one is significant. Chance could have entered into this result. However, the significant effect is predicted by our hypothesis. It occurs where we would predict it to occur, in the condition of the heaviest social loading. Nevertheless, the comparison in the Experimental groups of the two final decisions (t2 and t4) yields a nonsignificant result, even though it occurs in a critical comparison. Let us break down the Experimental and Control groups by sex of subject.

Figure 14

Probability that differences between time epochs occurred by chance, using two tailed paired t statistics on lateralization index. ⟶ = shift toward greater right hemispheric contribution. ⟵ = shift toward greater left hemispheric contribution.

Time Epochs	All E+C N=56	All E N=20	All C N=36	Male E N=8	Male C N=20	Female E N=12	Female C N=16
T1-2							
t	-0.07	-0.61	0.61	0.56		-1.68	-1.04
P	.94	.55	.54	.59 ⟵	.01 ⟵	.12 ⟶	.31 ⟶
T2-3							
t							
P	.63	.52	.99	.52	.32	.29	.42
T2-4							
t	0.27		0.58	-1.38		0.56	-0.46
P	.79	.84	.56	.20 ⟶	.19 ⟵	.58 ⟵	.65 ⟶
T3-4							
t	-0.44	-2.64	0.89	-1.27		-2.57	0.61
P	.66	.02	.38	.25 ⟶	.53 ⟵	.03 ⟶	.55 ⟶
df	55	19	35	7	19	11	15

Looking at the Male Control group, we find a highly significant difference between the Phase I initial and final decision. At .01 probability, the nonmanipulated Male Controls were likely to move toward more left hemisphere activity. As the study proceeded, the Control Males continued to use relatively more left hemispheric activity, though not significantly so. Nonmanipulated males are likely, on the average, to produce lateralization indices over trials which suggest that males handled the task in left hemispheric fashion, never breaking out of that mode.

The Male Experimental group shows that they, too, in the first phase comparison of initial t1 and final decision t2, tended to move toward a left hemispheric mode, though not significantly so. In Phase II, the Experimental Males have moved toward the right hemispheric mode (t3-t4), though not significantly so ($t = -1.27$, $p = .25$). Nevertheless, for the males, the comparison is in accord with predictions. Further, the comparison of the two final decisions (t2-t4) shows movement toward the right hemisphere ($t = -.138$, $p = .20$). In both of these critical comparisons, if the social loading hypothesis is to be tested, we find a movement toward the right as social loading is increased. That is not the case in either of the parallel control comparisons, where movement is toward the left.

The Female groups show both Controls and Experimentals moving toward increased right hemispheric involvement in Phase I, going from t1 to t2, the initial and final decisions. For the Female Control condition, none of the associated probabilities are significant, although the direction of movement seems to be consistently toward the right. In the Female Experimental group, we find a statistically significant two-tailed t probability in the t3 to t4 comparison ($t = -2.57$, $p = .026$, two-tailed).

2. Summary

In summary, we find that on this most aggregated of data the hypothesis of social loading is supported in the t3-t4 comparison for both male and female subjects. It is not supported in the comparisons of the two final decisions (t2 and t4) where our hypotheses led us also to expect differences. The Male Experimentals are in the right direction, as are All Experimentals taken together in comparison with the Controls. However, the Female groups provide evidence in favor of the hypothesis only within Phase II, the initial t3 and final t4 choice comparison. We would have expected the Female groups to provide support at the Phase I final and the Phase II final comparison (t2-t4) as well, and they do not. Moreover, the Male Controls and the Female Experimentals suggest that the first phase is an important comparison. Perhaps the initial and final decision per se contribute to the effects we have seen.

3. Alternative Data Presentation

Figures 15, 16, and 17 present the foregoing data in a modified way, in order to make comparisons clearer. Again, we present data which permits a comparison of the subjects taken as an aggregate in order to make a first assessment of our hypotheses and approach.

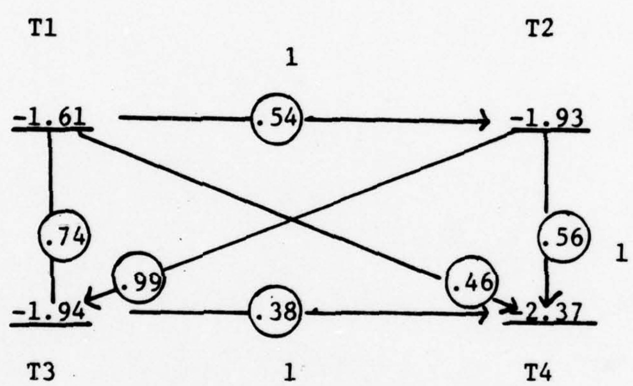
First, we compare All Experimentals and All Controls, regardless of sex of subject, using the laterality index described above. The visualization permits the means for each decision epoch in each phase to be displayed along with standard deviations and the appropriate t probabilities for each comparison. First, the aggregate for All Experimentals and All Controls is presented, followed by that for all Male Experimentals and all Male Controls. Finally, the Female Experimentals and Female Controls

Figure 15

Comparison of All Experimental and All Controls between time epochs on laterality index using two tailed, paired t tests.

— : mean taken over trials in time epoch
○ : probability that difference is due to chance
l or r : direction of movement with respect to hemispheres

All Controls:
N=36
F=16
M=20



All Experimentals:
N=20
F=12
M= 8

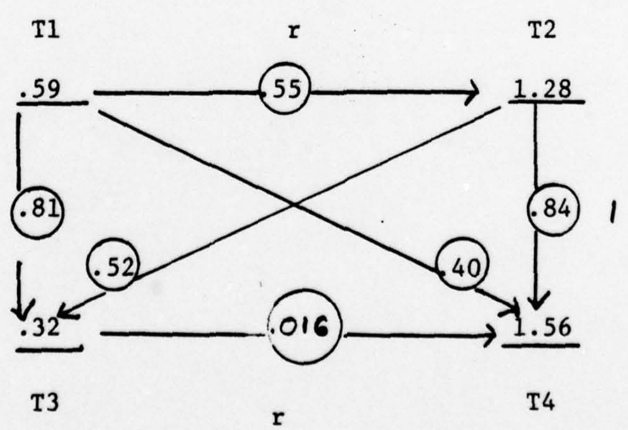
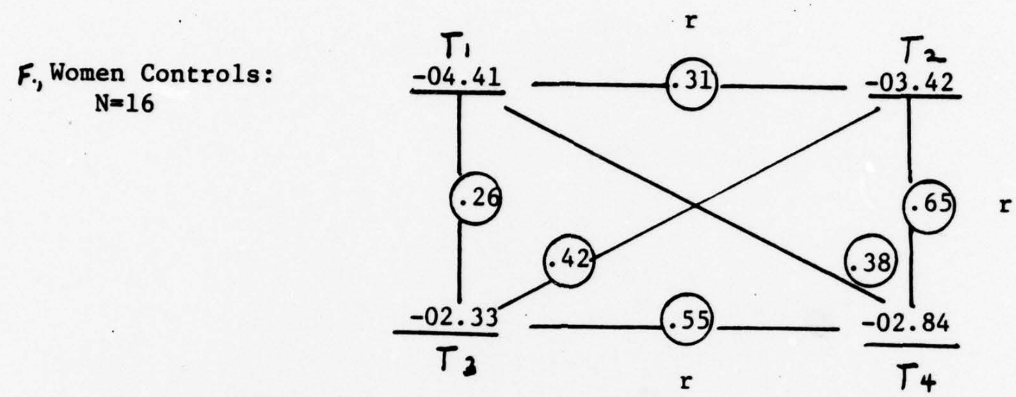


Figure 16

Comparison of women experimentals and controls on right dom, t tests, two tailed.



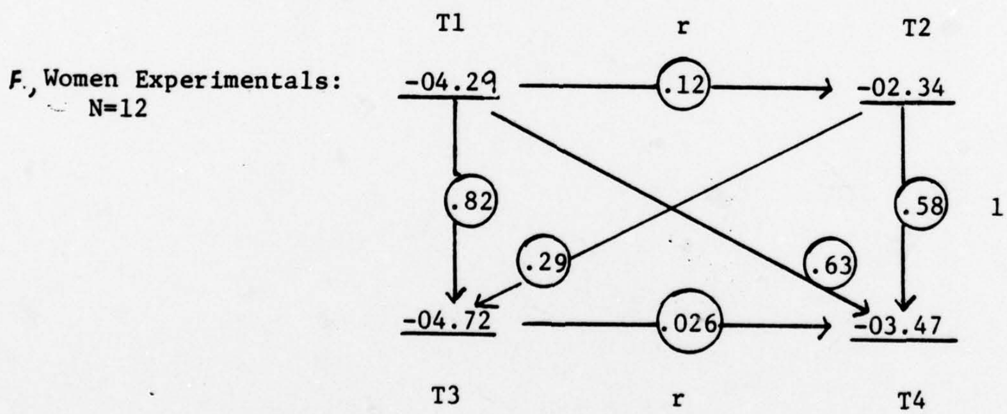
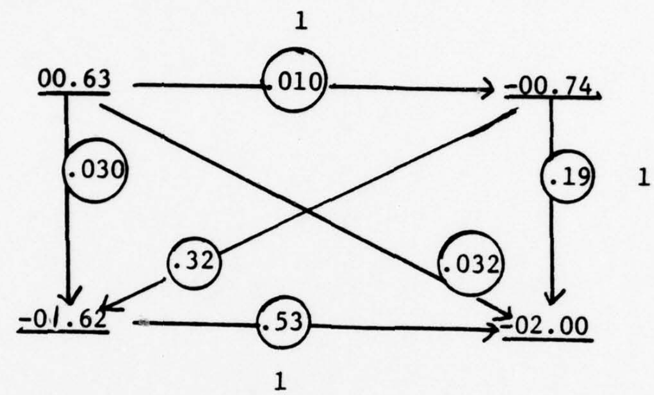


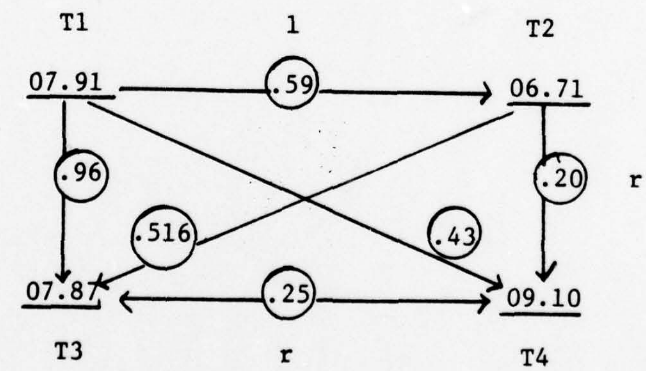
Figure 17

Comparison of men experimentals and controls using t tests, two tails.

Men Controls:
N=20



Men Experimentals:
N=8



are presented. It also should be remembered that within conditions each subject served as his or her own control for epoch comparisons. The purpose of these tables is not to present new data but to present more complete data of the sort already described, and in a way that the reader can see what is happening.

It would appear that in the Control condition, men are shifting to the left and that in the Experimental condition, which reflect social loading, they are shifting to the right. For the women, we find a tendency in the Control condition for the shift to be to the right. In the Experimental condition, the direction of the shift is to the left with the exception of the critical measure taken, reflecting partner feedback, which is to the right.

C. <u>Comparison of Shifts</u>

We now turn to a direct comparison of the shift which occurred in Phase I and Phase II. To do this, we subtract the lateralization index for t2 from t1, to create a statistic which indicates the difference in shift between initial and final decisions for each phase. We have called this the shift variable because it represents shifts within a phase. In Figure 18 the data on the shift variable is presented for Experimentals and Controls, by Phase I and Phase II, with standard deviations and standard errors entered below each shift mean. t probabilities for the likelihood that the differences between the Controls and the Experimentals occurred by chance are also entered. We present the data for All Experimentals and Controls aggregated, and for all Male Experimentals and all Male Controls, and for all Female Experimentals and all Female Controls.

Figure 18

Means, standard deviations and standard errors for shift variables for controls and experimentals for Phase I and Phase II. t test assesses probability that differences in shift between Phase I and Phase II occurred by chance.

	Categories	Phase	Controls	Experimentals	t probability
all:	experimentals = 20	P.I	-00.32	00.68	.42
	controls = 36		03.2	05.0	
			00.5	01.1	
		P.II	-00.43	01.27	.015
			02.9	02.1	
			00.5	00.5	
men:	experimentals = 8	P.I	-01.36	-01.19	.93
	controls = 20		02.2	06.1	
			00.5	02.1	
		P.II	- .0038	.0125	.0125
			27.	27.	
			00.6	01.	
women:	experimentals = 12	P.I	00.97	01.92	.52
	controls = 16		03.8	03.9	
			00.9	01.1	
		P.II	00.49	01.28	.078
			03.3	00.8	
			01.7	00.5	

However, it is only the comparisons of the Females which are legitimate across conditions, for design and randomization reasons.

1. Data and Interpretation of Shift Comparisons for Experimentals and Controls

We see that in each Phase I comparison the differences between Experimentals and Controls on the shift variable could well have occurred by chance. For each of the Phase II comparisons, the differences are attributable to chance only at the level of .07 or less.

We expected that there would be less difference between Experimentals and Controls in Phase I, as the social loading elements had not come into play (except for anticipation of the Experimentals that they eventually would be working with a partner). We expected the difference to occur in Phase II comparisons, in which the full effect of the manipulations would be called into play. We take these results as partial support for the social loading hypothesis.

2. Data and Interpretation of Shift Comparisons for Varying Data Combinations

Figure 19 shows the means, standard deviations, and standard errors for all possible combinations on the shift variable. The statistic presented is the F statistic.

The data show a difference between All Experimental and All Control subjects taken as an aggregate, which is placed at the .02 level for Phase I and the .13 level for Phase II. In both phases, Experimental subjects showed a positive signed mean, indicating that there was a shift to the right, while the Control subjects, taken as an aggregate, showed a negative signed score, indicating a shift to the left. These results are

Figure 19

Means, standard deviations, and standard errors of shift variable, reflecting the shifts which occurred from initial to final decisions in Phase I and in Phase II. F statistic assesses probability that differences between categories occurred by chance.

Phase	Categories	Means	Standard Deviation	Standard Error	F Probability
P.I	36 all C	-000.32	003.2	000.5	.02
	20 all E	000.68	005.0	001.1	
P.II	36 all C	-000.43	002.9	000.5	.132
	20 all E	001.27	002.1	000.5	
	Males				
P.I	20 MC	-001.36	002.2	000.5	.000
	8 ME	-001.19	006.1	002.1	
P.II	20 MC	-000.38	027.	000.6	.880
	8 ME	001.25	027.	001.0	
	Females				
P.I	16 FC	00.97	003.8	000.9	.872
	12 FE	01.92	0.039	001.1	
P.II	16 FC	-00.49	003.3	000.8	.035
	12 FE	01.28	001.7	000.5	
	All E				
P.I	8 ME	001.19	006.1	002.1	.194
	12 FE	001.92	003.9	001.1	
P.II	8 ME	001.25	02.7	01.	.171
	12 FE	001.28	01.7	00.5	
	All C				
P.I	20 CM	-001.36	02.2	00.5	.025
	16 FM	000.97	03.8	00.9	
P.II	20 CM	-000.38	002.7	000.6	.383
	16 FM	-000.49	003.3	000.8	

in the direction of our social loading hypothesis, are generally true for both phases, but show significance only for the first phase. The results suggest that the task setting exerted an influence on the subjects, diminishing differences over time.

Males reflect a pattern similar to that described above. Females, however, show no difference between Experimentals and Controls on the shift variable reflecting Phase I ($p = .880$). However, they show a significant difference in Phase II ($p = .035$). The female data, in which we have the most confidence, supports the social loading hypothesis.

We also compared Control Males with Control Females, and Experimental Males with Experimental Females. We cannot legitimately make these comparisons, but report them because they are suggestive of lines of investigation which may be fruitful or are suggestive of pitfalls to be avoided in future research. On these comparisons, we find no significant differences in either phase in the Experimental group comparisons of males and females. However, in the Control conditions we find a significant difference in the first phase ($p = .025$), which diminishes to insignificance in the second phase ($p = .383$). Our interpretation of this, were it to be confirmed in a properly replicated study in which sex was a variable, would be that the task diminishes differences between males and females, such that the initial differences with which they entered the situation are lessened through the process of being in the same kind of situation.

Comparing across conditions, we find that the females exactly support our predictions in that the difference between Controls and Experimentals was significant only in Phase II. Direction is not easily obtained from this data, and we use it to show differences in shift only.

However, reference to Figure 19 shows that in the final decision of the second phase, Female Experimentals did indeed shift to the right hemisphere compared with the first decision of that phase.

From this data on the shift variable for the female groups in which we have most confidence, we conclude that there is a difference between Phase I and Phase II. The data coincides with our social loading hypothesis predictions in that the subjects differed in Phase II but not in Phase I, and the difference is in the direction of a greater right shift in Phase II.

3. Direction of Shift without Regard for Numerical Scores

a. Aggregate by Sign

Figure 20 presents notations of the direction of shift by condition, without regard to numerical scores, when comparisons across decisions of time periods are made. The t1-t2 comparison represents first phase, t3-t4 comparison represents second phase, t1-t3 represents a comparison of the initial trials in each phase, and t2-t4 represents a comparison of the final decision of each phase.

An immediate difference is that the Males and Females in both Experimental and Control conditions are the reverse of each other in Phase I, with the women moving to the right hemisphere, relatively, and the men moving to the left hemisphere, relatively, in the t1-t2 comparison. In the Control conditions, the Males and Females are both shown to have shifted toward left hemisphere activity in the t3-t4 comparisons. This represents a continuation of an initial predisposition for the Males and a change for the Females. In the Experimental conditions, the Males show a shift to the left in Phase I, as they did in the Control condition,

Figure 20

Comparisons between time epochs without regard for numerical values to show direction of hemispheric shift. Subjects serve as own control.

Phase Time Epoch	FE	FC	ME	MC
T1 - 2	r	r	l	l**
T3 - 4	r***	l	r	l
T1 - 3	l	r	(no change)	l*
T2 - 4	l	r	r	l

***significant at .026, two tailed paired t
**significant at .01, two tailed paired t
*significant at .03, two tailed paired t

and they show a shift to the right in Phase II. The Experimental group of women show a shift to the right in Phase I and an intensification of the shift to the right tendency in Phase II.

Thus, both males and females show a directional consistency, by sex, across Experimental and Control conditions in Phase I. Although both males and females show support for the social loading hypothesis in phase comparisons on the Experimental groups, it is not at all clear that they get there the same way.

b. Percent of Subjects Shifting to Right

We again make use of the lateralization index but in a different manner in order to capture something of the individuals who exhibited a shift. Percentages are used in order to compensate for unequal Ns within conditions. In this index, a negative score indicates more right hemisphere alpha. As alpha is taken to represent "wakeful restfulness," it is an indicator within subjects of the brain less involved in the task. A negative laterality index score represents relatively more left hemisphere activity. This is because the right hemisphere, by our assumptions, is producing more alpha and is taken to be relatively more at rest. Therefore, the sign of laterality index reveals the hemispheric mode in which the subject processes the task. We turn, in Part V, to questions of the hemispheric mode. Here, our primary concern is with relative changes in the hemispheric balance, regardless of mode in which the task was approached.

Shifts to the right may occur in three ways: right hemispheric mode may become more right; left hemispheric mode may become less left, and left hemispheric mode may become right. Each of these is a way for the

hemispheric balance to shift so that the right hemisphere is contributing relatively more activity than in a comparison period.

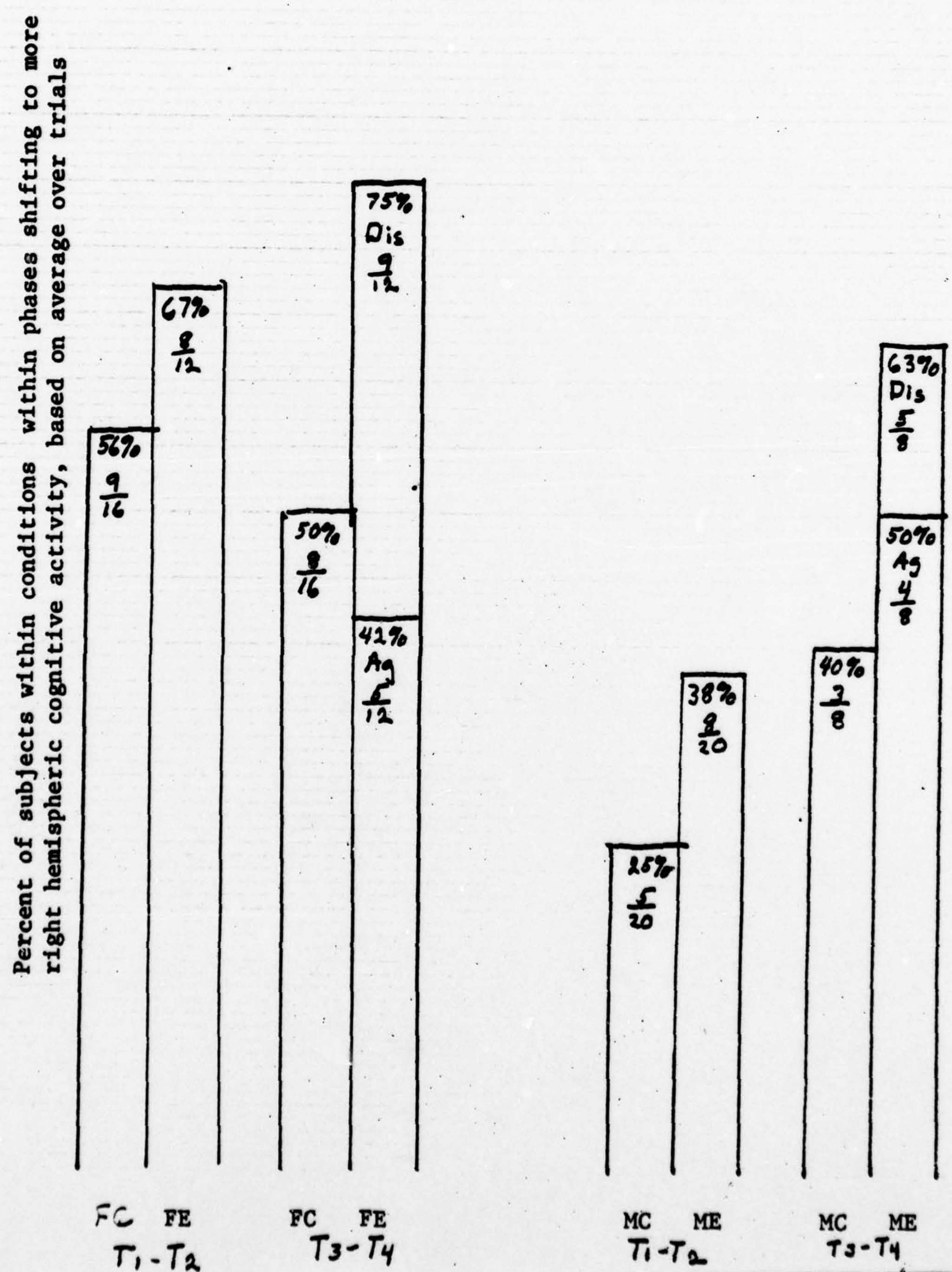
The basic hypothesis of the studies conducted was that in the presence of social loading individuals would tend to shift to right hemispheric cognitive activity. It should be noted that this is different than having dominant activity in the right hemisphere. Rather, it is a reflection of relative contribution of the hemispheres. Indeed, there were a few individuals whose shift caused the balance to tip from one hemisphere to another, but that is not the focus of this analysis.

The critical comparisons in our setting are between Phase I and Phase II, for that is where the social loading factors come into play. Accordingly, we have graphed the percentage shifts to the right for male and female Control groups from t1 to t2, in Phase I, and from t3 to t4 in Phase II. For the Experimental groups, we used the disagreement trials, although agreement trials are sketched in for reference. It should be remembered that the experimental setting is such that each phase requires an initial and a final choice. Prior to the second phase, the Experimental groups were told that they and their partners did well on the previous phase and are then confronted with 80% disagreements from the partner.

Figure 21 graphically presents the percentage of persons who shift to the right from Phase I initial choice to Phase I final choice (t1-t2), and from Phase II initial choice to Phase II final choice (t3-t4). For the Phase II Experimental conditions, we differentiate between the 80% partner disagreements and the 20% partner agreements.

The graph shows that, independent of cognitive mode in which the first slide series was viewed, 56% of the Female Controls shifted to the right from t1 to t2 and that 50% shifted to the right from t3 to t4. This

Figure 21
Percentage of Shifts Toward More Right Hemispheric Contribution to Hemispheric Balance: Within Phases for Each Condition



contrasts with the Female Experimentals (who anticipated working with a partner later, who were manipulated into an HH condition, and who received 80% disagreements). From t1 to t2, 67% of the Female Experimentals shifted to the right. With disagreements, that percentage went up to 75% from t3 to t4. This suggests that, in fact, the presence of social factors does occasion a greater probability of right shift when task is held constant. (It is interesting to note that among the females the lowest probability of a right shift is on agreement trials. This suggests that it is discrepant information rather than any information at all which will occasion the postulated shift. It is our belief that had we chosen a more powerful manipulation greater shift would have occurred both in frequency and in intensity.)

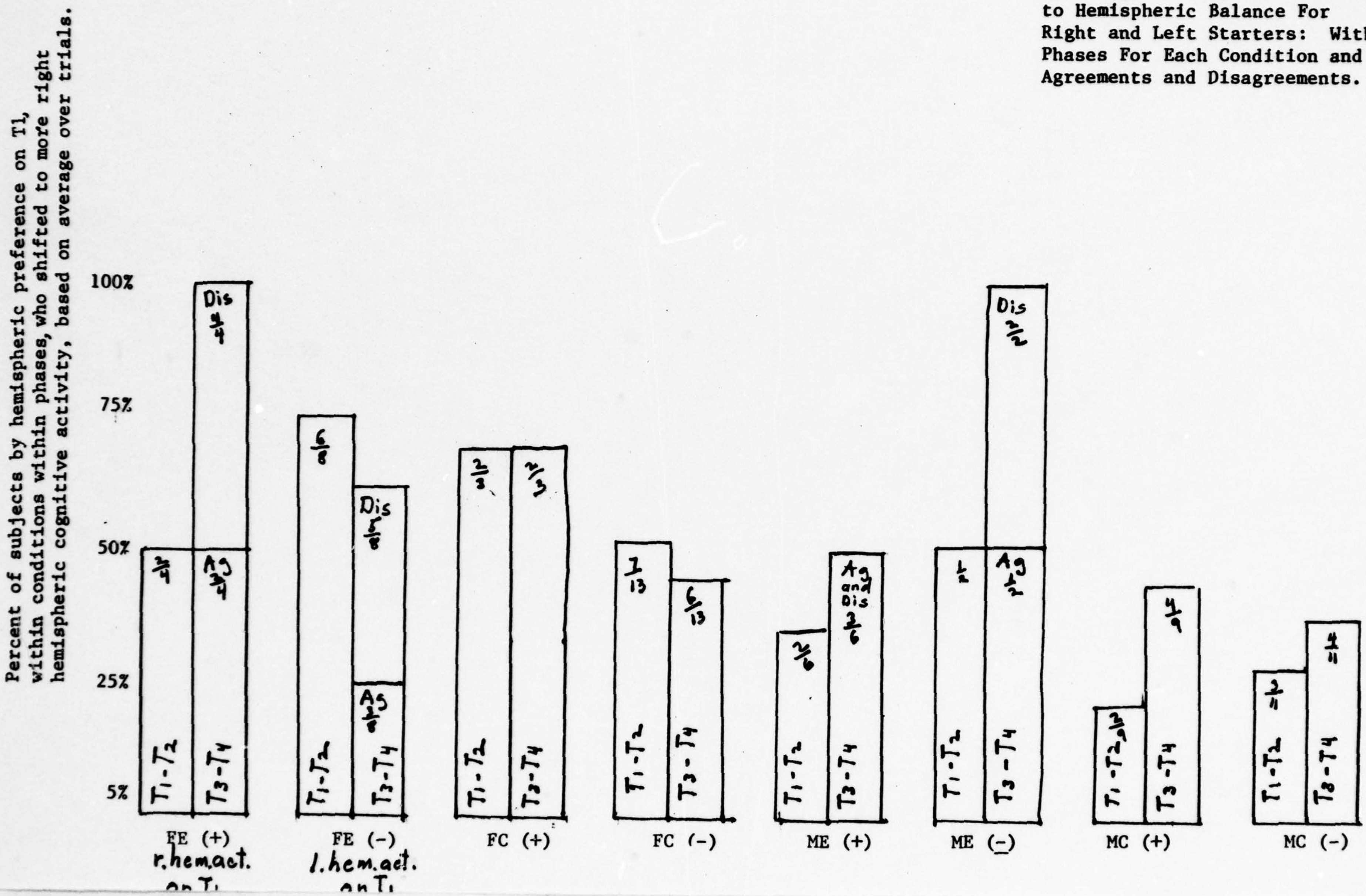
The males, in general, reflect a lower percentage of shifts occurring, comparing them with the females. However, the direction is the same. As with the women, the men exhibited a greater percentage shifting to the right in the Experimental than in the Control condition. Further, the disagreements occasioned the largest percentage of shifts.

c. <u>Percent Shift by Right or Left Starters at t1</u>

We have earlier expressed our concern over the difference in sign across subjects with which they performed the t1 decisions. Figure 22 presents a graph showing the relative percentage of shifters within Phase I and Phase II by condition. The reasoning outlined for the preceding section applies here as well.

Within the female group, we see that 50% or more of the subjects shifted to the right from each t1-t2 epoch, a finding which holds for both Experimental and Control conditions for both right and left starters. On

Figure 22
Percentage of Shifts Toward More Right Hemisphere Contribtion to Hemispheric Balance For Right and Left Starters: Within Phases For Each Condition and by Agreements and Disagreements.



the t3-t4 comparison, less than 50% of the Control Females shifted to the right. On the t3-t4 comparison, for those Experimental Females who were positive starters, we see all subjects showing a right shift on disagreement trials, with 50% showing a right shift on agreement trials. For those Experimental Females who are negative starters, we see, for both agreement and disagreement trials, a lower percentage of right shifters than was the case in t1-t2. Disagreement trials produce a greater percent shifting than do agreement trials.

For the male groups, we see that in the Experimental group both the positive and negative starters produce more shifts to the right than do the Control group. For both negative and positive starters in both conditions, we see a percentage shift to the right in t3-t4. However, in both t1-t2 and t2-t3, Experimental Males show a higher percentage of right shifters than do Control Males. This is also true for the female negative starters, excluding agreement trials.

D. Summary of Aggregate Analyses

From these analyses of the aggregated laterality index and shift variables, we find that the social loading hypothesis is supported in the phase comparisons, there being a greater shift to the right in Phase II than in Phase I for the Experimentals but not for the Controls. Within Phase II, the t3-t4 comparison is significant for the Experimentals but not for the Controls. More men and women shifted to the right on disagreement than on agreement trials. These findings support the social loading hypothesis.

A surprise in the data came from the apparent sex differences. Men and women both move toward relatively more right hemispheric contribution under conditions of social loading but do so from a different base. In

this setting and on this task, women were more "left brain" and the men more "right brain." The data also suggest that the social setting may act to diminish the initial sex differences. Thus, from the research there emerge factors which are interesting in and of themselves, on the one hand, and which should be taken into account in future designs, on the other.

A potentially important, though inadvertent, finding is that anticipation of social interaction may produce an effect similar to that of actual interaction. Both anticipated and real social interaction produce movement toward increasing the right hemisphere's contribution, although it is with real interaction that the movement becomes significant statistically.

Although the data were generally supportive of the social loading hypothesis, we have found the variance to be large, suggesting the necessity for looking at individual differences. In this Part, we approached that question by asking what percentage of the subjects within a condition showed a shift to the right within Phase I and Phase II. Although we found that the number of subjects within a condition who actually shifted to the right is in line with the data reported on the comparisons of the means, it is apparent that not all subjects demonstrated such a shift, thereby suggesting that a portion of the subjects were providing the movement which caused the statistical support for the hypothesis.

We noted that some subjects showed a negative and some a positive sign on tl. From that observation, we conclude that people differ as to the way they handle the Spatial Judgment task. We will take those differences into consideration in the next Part.

In conclusion, we find that our hypothesis of social loading is supported in the main by the aggregate data analysis and that further analyses are appropriate, taking into account the cognitive mode with which the subjects approached the task.

V. LATERALITY ANALYSIS BY COGNITIVE MODE

Hemispheric lateralization of alpha activity is an index of the relative activity or inactivity of the two hemispheres of the brain, independent of absolute values of alpha production. The laterality index is a measure of this relative balance between the hemispheres. Laterality indices are computed according to the following formula:

$$\frac{LH - RH}{LH + RH} (100).$$

This algorithm has several nice properties. It allows the relative alpha output of the two hemispheres to be expressed as a percent difference of the total alpha activity. Positive laterality indices indicate the percent more alpha activity in the left hemisphere. Negative laterality indices indicate the percent more alpha in the right hemisphere. A laterality index equal to zero indicates that there is equal alpha activity in both hemispheres.

Alpha activity is taken to represent a resting or "idling" frequency of the brain. When a subject is working on a task, the hemisphere with the most alpha activity is taken to be less actively engaged on the task than the other hemisphere. Therefore, from a positive laterality index (more alpha in the left hemisphere) we infer that the right hemisphere is more actively engaged on that task. Similarly, from a negative laterality index (more alpha activity in the right hemisphere) we infer that the left hemisphere is more actively engaged in task activity. We use the phrase "right hemispheric cognitive mode" to refer to more right hemispheric activity on the task. We use the phrase "left hemispheric cognitive mode" to refer to more left hemispheric activity on the task. Thus, for any given task an individual can be characterized on the basis of a

laterality analysis as employing a relatively greater left or right hemispheric cognitive mode in solving the task.

In the analysis of laterality indices, we first calculate a laterality index for each decision epoch on each trial for each individual. Then we calculate an average laterality index for each individual for each decision epoch by averaging together the laterality indices for each trial. These average individual laterality indices for each decision epoch are then averaged together to obtain an average across individuals, or an average for a given condition, for each of the decision epochs. The averages by condition for each decision epoch are the data we analyze. Decision epochs are referred to as t1, t2, t3 and t4. Epoch t1 is the initial choice in Phase I. Epoch t2 is the final choice in Phase I. Epoch t3 is the initial choice in Phase II, and epoch t4 is the final choice in Phase II. The data which follows is based on these calculations. In Appendix A we present an analysis of laterality indices standardized by resting laterality baselines for each subject.

In discussing changes in laterality indices between decision epochs, we use the terms "increase" and "decrease." An increase in the value of the laterality index may represent one of three kinds of changes: 1) a change from a negative laterality index to a positive laterality index, 2) a change from a negative laterality index to a less negative laterality index, or 3) a change from a positive laterality index to a more positive laterality index. Each of these is taken to represent a relative increase in right hemispheric utilization. Similarly, a decrease in the laterality index may represent one of three kinds of changes: 1) a change from positive to negative, 2) a change from a positive to a smaller positive value, and 3) a change from a negative value to a more negative value. Each of

these is taken to reflect a relative decrease in right hemispheric utilization.

In discussing changes in laterality indices between decision epochs, we at times use the phrase "more right hemispheric" or "more left hemispheric." More right hemispheric means any of the changes we refer to as increases in the above paragraph (an increase in the relative amount of left hemispheric alpha, or increases in right hemispheric involvement on the task). A change is more left hemispheric if the change is what we called a decrease in the previous paragraph, which represents a relative increase in right hemispheric alpha.

As noted in Part IV, it was observed that the Spatial Judgment task is not hemispheric specific across subjects. That is, some subjects seem to approach this task from a left hemispheric cognitive mode, while others approach it from a right hemispheric cognitive mode. Since we are interested in looking for shifts in cognitive mode among individuals, we have separated the subjects into two groups, those who approach the task in a left hemispheric mode and those who approach the task in a right hemispheric mode. This was accomplished by taking the average laterality score at t1 for each subject as the indicator of hemispheric mode. Subjects whose t1 laterality index was positive were assigned to the right hemispheric mode group, and subjects whose t1 laterality index was negative were assigned to the left hemispheric mode group. (These two groups are designated by (+) and (-), respectively, in subsequent portions of the text.)

A. Stage One: Male Experimental Condition

1. Data

Figure 23 presents data on the Male Experimental condition for the laterality scores by decision epoch: a) for all subjects combined, b) for the subjects with positive t1 laterality indices, ME(+), (right hemispheric cognitive mode), and c) for the subjects with negative t1 laterality indices, ME(-), (left hemispheric cognitive mode). Since there are only two subjects in the ME(-) group, no conclusions will be drawn from this data.

Focusing on the subjects who had positive laterality indices at t1, ME(+), we find that there are no statistically significant differences across any of the decision epochs or agreement/disagreement trial comparisons. This may be due to the small number of subjects involved (N = 6). We therefore examine the data to see if there is a consistent pattern. We note that there is a drop in the laterality index from t1 to t2; it then moves back up at t3, and at t4 continues up for disagreement trials, but goes down for agreement trials. Going up means more of a right hemispheric cognitive mode; going down indicates a more left hemispheric cognitive mode. Thus, processing shifts more to the left hemisphere from t1 to t2. This may be associated with an easier task in t2, simply checking on the previous judgment. There is a similar left shift from t3 to t4 for agreement trials. These trials also may represent simply a checking to see if my opinion holds, but there is not much concern, because my opinion has already been validated by my partner. In contrast, where there is disagreement from the partner, it is not a simple checking operation, but a matter of more complexity. My partner, who is good, and as good as I am,

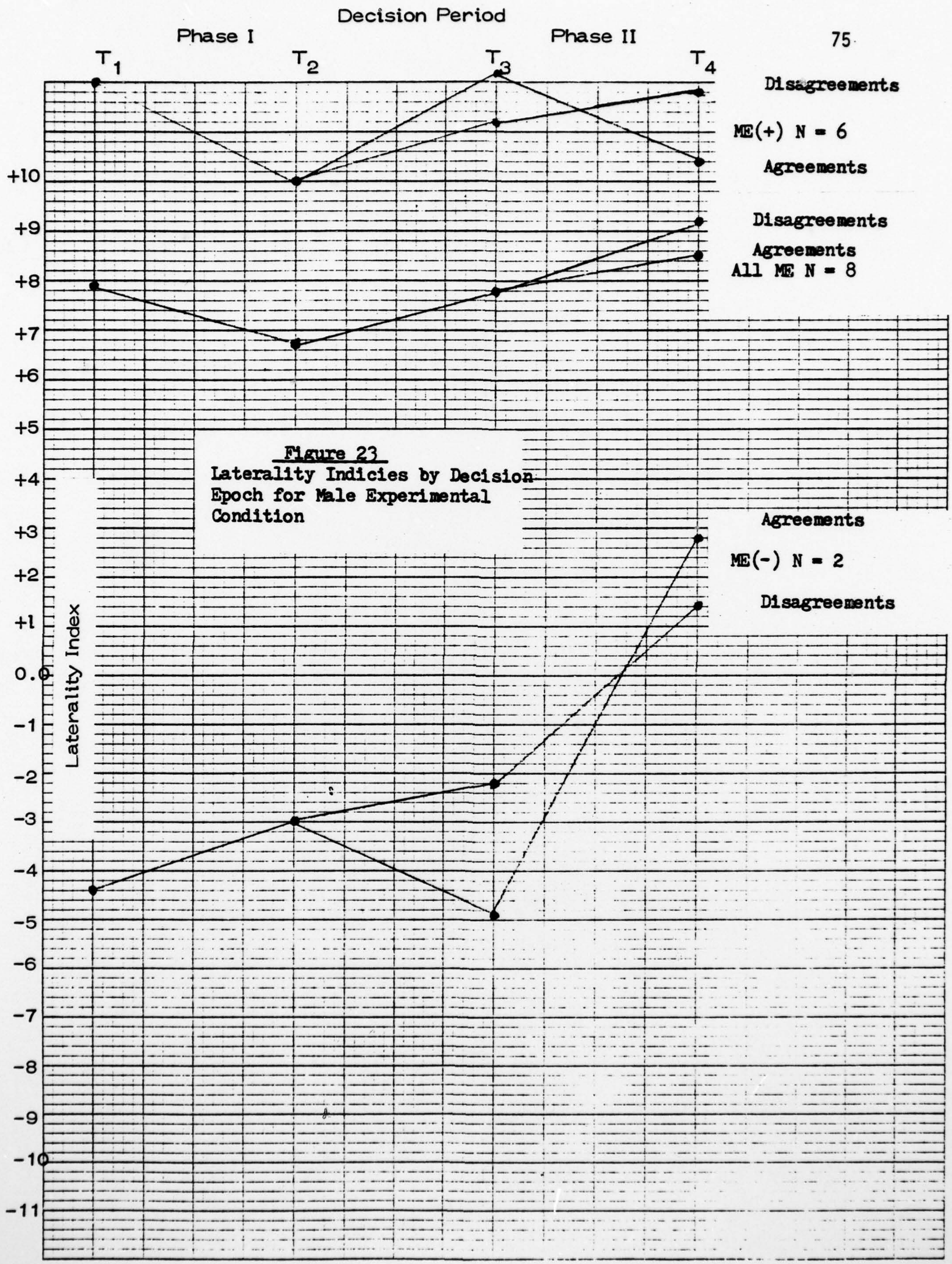


Figure 23
Laterality Indicies by Decision Epoch for Male Experimental Condition

disagrees with me. How am I to resolve this dilemma? In this situation, we see a shift to the right cognitive mode. Thus, shifts to the right may represent a) novelty (as in initial viewings of a problem), b) complexity (as in disagreement from a partner), or c) the effect of social loading in Phase II. Shifts to the left may be associated with routine checking of first impressions where no novelty or dilemma is present.

For those subjects (N = 2) who had negative laterality indices at t1, the data is uninformative because their patterns of increase and decrease over decision periods is not consistent.

2. Interpretation

Our conclusions from this analysis are tentative at best. No statistical differences were found. This may be due to the small number of subjects. Thus, we are left to discuss in an intuitive manner the patterns in the data. It has been suggested that novelty (as in initial viewings of a problem) and complexity (as in disagreements from a partner who is equally highly competent as the subject on the task), or social loading may produce higher laterality scores, representing a shift toward a more right hemispheric mode of cognitive processing. Routine checking on a decision which has already been made, wherein no novelty or complexity is presented, may be associated with lower laterality indices, representing a more left hemispheric mode of cognitive processing for these Male Experimental subjects.

B. Stage Two: Male Control Condition

1. Data

Figure 24 presents laterality indices by decision epoch for: a) all

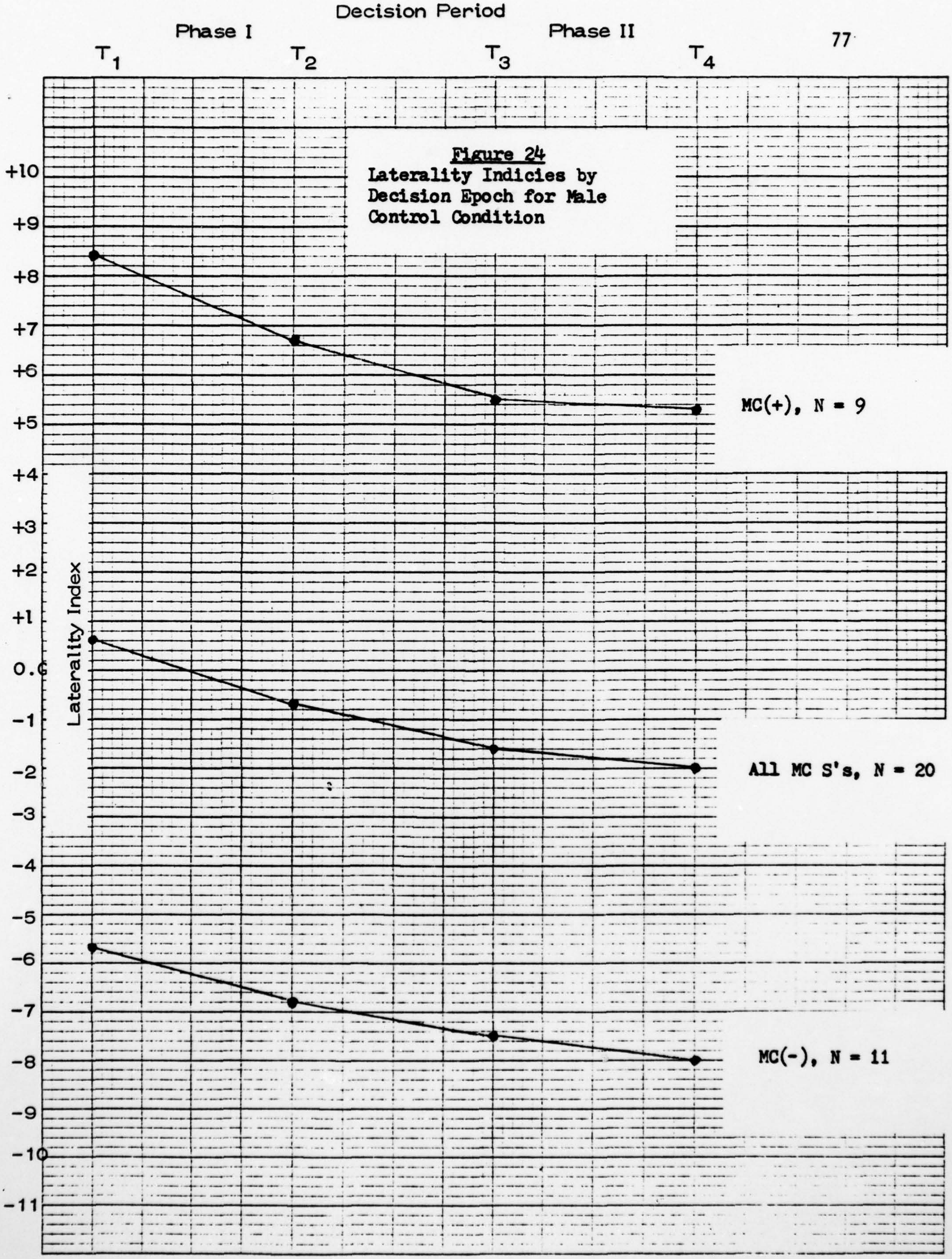


Figure 24
Laterality Indicies by Decision Epoch for Male Control Condition

Male Control subjects, b) the subjects with positive tl laterality indices, MC(+), and c) the subjects with negative tl laterality indices, MC(-). In all cases, the laterality indices decrease over decision epochs. Statistical tests are presented in Figure 25 for MC(+) subjects (N = 9) and in Figure 26 for MC(-) subjects (N = 11).

Overall, the statistical tests indicate downward movement over time, but several of the comparisons fail to reach significance, apparently due to wide variance in individual subject behavior.

2. Interpretation

Laterality indices over time in this setting tend to go down slowly for both the MC(+) and the MC(-) groups. There is much variance among individuals with regard to direction and the amount of change.

This downward trend over time is consistent with our previous interpretation that novelty and complexity or social loading increase the laterality index. In the Control condition, there is no novelty, complexity, or social loading introduced, so the laterality indices should go down.

C. Comparison of First and Second Stages

The subanalysis for the Male Experimental condition for which we have the most subjects ME(+), N = 6, indicates that the laterality index increased due to increased involvement stemming from novelty, complexity, and/or social loading. This idea is also consistent with the Male Control data, wherein, in the absence of novelty, complexity, and/or social loading, laterality indices decrease.

Comparison of Control and Experimental groups, for subjects whose tl laterality indices were positive, indicates that they are not statistically

Figure 25

Summary of One-tailed t-Tests on Differences
in Laterality Indices for Male Control (+) Condition (N=9)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	2.27	8	.025
t2 vs. t3	-	8	n.s.
t3 vs. t4	-	8	n.s.
Between phrases:			
t1 vs. t3	1.45	8	n.s.
t2 vs. t4	-	8	n.s.

Figure 26

Summary of One-tailed t-Tests on Differences
in Laterality Indices for Male Control (-) Condition (N=11)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	1.70	10	.10
t2 vs. t3	-	10	n.s.
t3 vs. t4	-	10	n.s.
Between phases:			
t1 vs. t3	2.34	10	.025
t2 vs. t4	1.51	10	.10

different either in t1 or t2 of Phase I but that they are statistically different at t1 and t2 in Phase II on both agreement and disagreement trials. t-tests for these comparisons are presented in Figure 27. The laterality indices for the ME(+) group in Phase II are higher than those in the Control group, MC(+). Novelty presumably lessens for both groups in Phase II, but the Experimental group is subject to increased complexity and social loading in the form of working with a partner. This apparently serves to increase the laterality indices. (It is possible, however, that this difference is due to changes in equipment and calibration between Stage One and Stage Two.)

There are too few subjects in the ME(-) group to put much faith in their average scores, but in general a similar phenomenon seems to be occurring, with some anomolies. No statistical comparisons are attempted because of the small number of subjects (N = 2).

D. Stage Three: Female Experimental and Control Conditions

1. Data

Figure 28 plots average laterality indices for Female Control subjects: a) all together, b) whose t1 laterality indices were positive, FC(+), and c) whose t1 laterality indices were negative, FC(-).

There are no significant differences between decision epochs for the FC(+) subjects. This may be due to the small number of subjects in this group (N = 3).

For the FC(-) subjects, there are significant differences only between t2 and t3, and between t1 and t3. Since there are thirteen subjects in this group, we may have some confidence in this data. Statistical

Figure 27

t-Tests for the Difference of Means
Between Male Control (+) and Male Experimental (+) Conditions
for Decision Epochs and Agree/Disagree Trials*

Decision Epoch	t value	df	Significance Level
1	.803	13	n.s.
2	.940	13	n.s.
3 (Disagreements)	1.554	13	.10
3 (Agreements)	2.201	13	.05
4 (Disagreements)	1.608	13	.10
4 (Agreements)	1.526	13	.10

*Alterations in equipment between Stage One and Stage Two require that this data be taken as suggestive only.

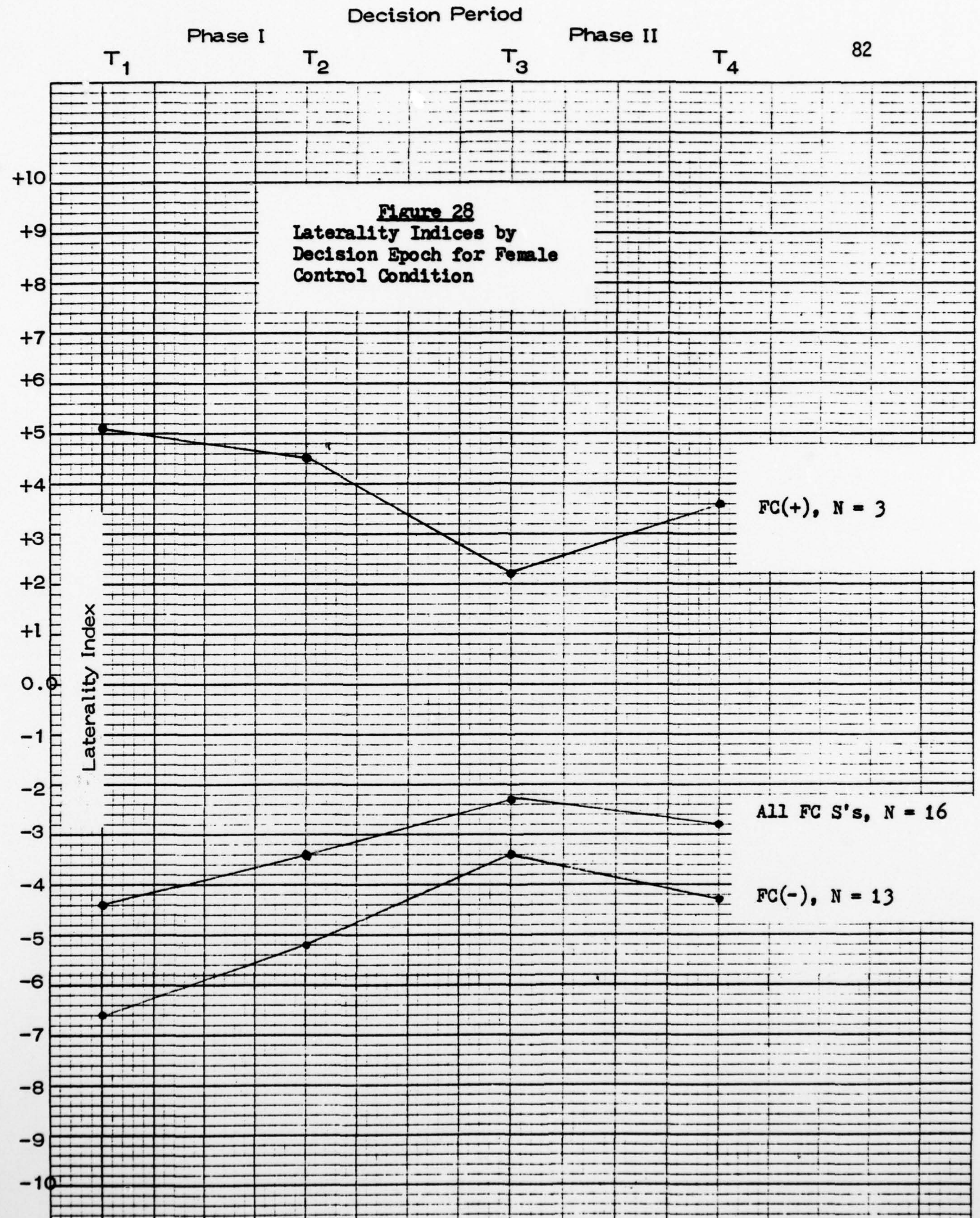


Figure 28
Laterality Indices by Decision Epoch for Female Control Condition

tests are summarized in Figure 29. The trend over time is for the laterality index to rise rather than go down, as it did in the Male Control (+) and (-) conditions. Here we see a significant rise in the laterality index from Phase I to Phase II.

One interesting observation to be made from Figure 28 is that laterality indices for the Female Control (+) and (-) conditions fall in a mirror image pattern. We will speculate on the possible significance of this later.

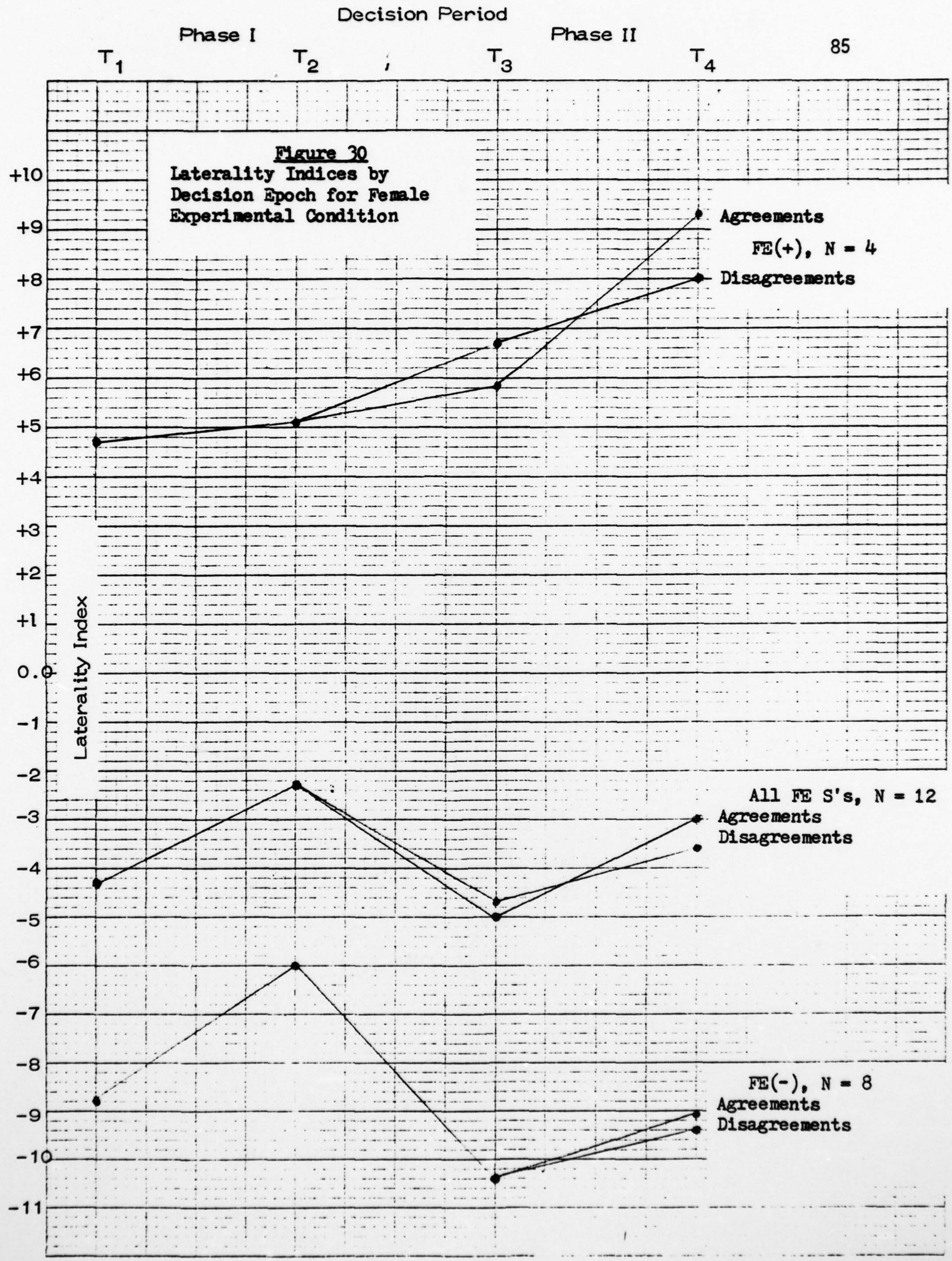
Figure 30 plots laterality indices for the Female Experimental (+) and (-) subjects and for both groups together. The Female Experimental (+) subjects, N = 4, show a rise in laterality index over the four decision epochs. Among adjacent decision periods, this rise is only significant between t3 and t4 for agreement trials. However, the small N may have precluded our finding differences when in fact they actually exist. Between phases we find a significant increase from t1 to t3 for disagreement trials but not for agreement trials. We also find significant increases from t2 to t4 for both disagreement and agreement trials.

The decrease from t1 to t2 found in the ME(+) group is not apparent here in the FE(+) group; there is no change from t1 to t2. Thus, whatever the effect of novelty on the FE(+) group, if indeed there is an effect, seems to sustain itself over initial and final decisions in Phase I. An increase at t3 is observed, although it is not statistically significant. Statistical tests are summarized in Figure 31. The effect of complexity or social loading seems to increase the laterality index from t3 to t4, but this increase is only significant for agreement trials. The laterality index for agreements is higher than for disagreements at t4, although not significantly. This is opposite to the ordering found in the ME(+) condition.

Figure 29

Summary of Significant One-tailed t-Tests on Differences in Laterality Indices for the Female Control (-) Condition (N=13)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	-	12	n.s.
t2 vs. t3	1.46	12	.10
t3 vs. t4	-	12	n.s.
Between phases:			
t1 vs. t3	1.63	12	.10
t2 vs. t4	-	12	.10



Decision Period
Phase I
Phase II
T_1
T_2
T_3
T_4
Figure 30
Laterality Indices by Decision Epoch for Female Experimental Condition
Laterality Index
+10
+9
+8
+7
+6
+5
+4
+3
+2
+1
0.0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
Agreements
FE(+), N = 4
Disagreements
All FE S's, N = 12
Agreements
Disagreements
FE(-), N = 8
Agreements
Disagreements

Figure 31

Summary of Significant One-tailed t-Tests
on Differences in Unstandardized Laterality Indices
for Female Experimental (+) Condition (N = 4)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	-	3	n.s.
t2 vs. t3 (Disagreements)	-	3	n.s.
t2 vs. t3 (Agreements)	-	3	n.s.
t3 vs. t4 (Disagreements)	-	3	n.s.
t3 vs. t4 (Agreements)	3.57	3	.025
Between phrases:			
t1 vs. t3 (Disagreements)	5.66	3	.01
t1 vs. t3 (Agreements)	-	3	n.s.
t2 vs. t4 (Disagreements)	3.53	3	.025
t2 vs. t4 (Agreements)	8.66	3	.005

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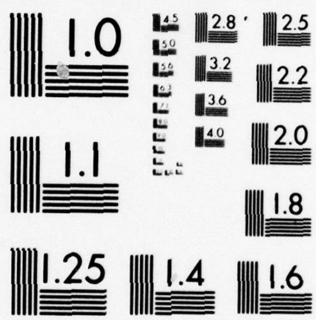

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

The data for the Female Experimental (-) subjects shows quite a different picture from that for the Female Experimental (+) subjects. The larger N in the FE(-) group may make this data more reliable (N = 8). Here we see a significant increase in the laterality index from initial to final choice in both phases and for both agree and disagree trials. Statistical analyses are summarized in Figure 32. There is also a significant drop between phases, from t2 to t3. No significant differences are found between agreement and disagreement trials. We do not compare the FE(-) group to the ME(-) group because of the small number of subjects in the Male group (N = 2).

Figure 33 compares Female Control (+) and (-) with Female Experimental (+) and (-) by plotting average laterality indices across decision epochs. Comparing Female Control (+) with Female Experimental (+), we see that there are no significant differences between laterality indices in either t1 or t2 in Phase I. In Phase II, however, there are significant differences for t3 and t4 for both disagree and agree trials. Summaries of these statistical tests are given in Figure 34.

This data is consistent with the idea that complexity or social loading in Phase II produces higher laterality scores. The ME(+) and MC(+) data is also consistent with this idea. Data for the FC(+) and FE(+) groups is not completely consistent with the ME(+) and MC(+) data in that the Phase I laterality indices for the FC(+) group are not lower than for the FE(+) group.

Comparing Female Control (-) with Female Experimental (-), we find a mirror image of the situation for the (+) conditions. For the (-) conditions, there is again no statistical difference between FC(-) and FE(-) in Phase I, for t1 and t2 scores; but in Phase II there is a significant

Figure 32

Summary of Significant One-tailed t-Tests
on Differences in Unstandardized Laterality Indices
for Female Experimental (-) Condition (N = 8)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	1.68	7	.10
t2 vs. t3 (Disagreements)	1.48	7	.10
t2 vs. t3 (Agreements)	-	7	n.s.
t3 vs. t4 (Disagreements)	1.54	7	.10
t3 vs. t4 (Agreements)	-	7	n.s.
Between phases:			
t1 vs. t3 (Disagreements)	-	7	n.s.
t1 vs. t3 (Agreements)	-	7	n.s.
t2 vs. t4 (Disagreements)	-	7	n.s.
t2 vs. t4 (Agreements)	-	7	n.s.

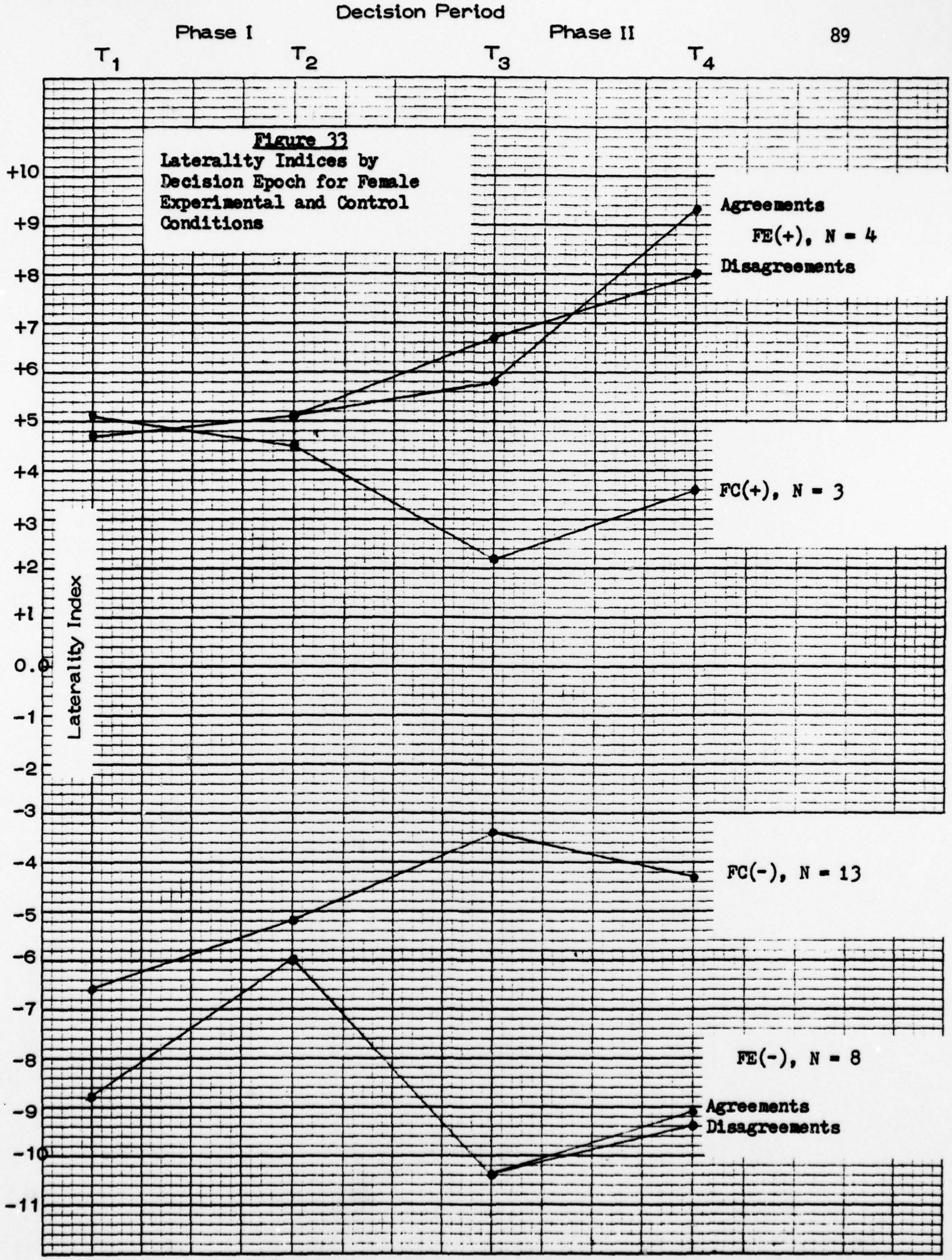
Decision Period
Phase I
Phase II
T1
T2
T3
T4
Figure 33
Laterality Indices by Decision Epoch for Female Experimental and Control Conditions
+10
+9
+8
+7
+6
+5
+4
+3
+2
+1
0.0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
Laterality Index
Agreements
FE(+), N = 4
Disagreements
FC(+), N = 3
FC(-), N = 13
FE(-), N = 8
Agreements
Disagreements

Figure 34

Summary of Significant One-tailed t-Tests
for Differences in Unstandardized Laterality Indices
Between Female Control (+) and Female Experimental (+) Conditions

Comparison	t Value	df	Significance Level
t1	-	5	n.s.
t2	-	5	n.s.
t3 (Disagreements)	1.978	5	.10
t3 (Agreements)	1.662	5	.10
t4 (Disagreements)	1.502	5	.10
t4 (Agreements)	2.176	5	.05

<u>decrease</u> in the laterality indices of the Experimental group at t3 and t4 relative to the Control group. In this case, the Experimental group (-) becomes more left hemispheric than the Control group (-) in Phase II. A summary of these statistical tests is given in Figure 35.

2. <u>Interpretation</u>

The novelty-complexity/social loading hypothesis does not fare well in light of this data. This hypothesis was supported by an inspection of the data on laterality indices for Male Experimental (+) subjects (N = 6). As noted, the data for Female Experimental (+) subjects is roughly in accord with the hypothesis, but the number of subjects is small (N = 4). The data for Female Experimental (-) subjects (N = 13) shows a pattern opposite to that of the Male (+) subjects, but data on Male Experimental (-), N = 2, seems roughly consistent with the Female Experimental (-). This suggests that subjects who perform the task in the right hemispheric cognitive mode, (+), may undergo different processes over time from those who perform the task in a left hemispheric cognitive mode (-). The present data is not sufficient to confirm this idea, because of small subject numbers, but it is an hypothesis which seems to order the observations.

An alternative explanation which orders the data is the following. Assume that the variations in Control condition measurements are really not meaningful; i.e., that there is no change in Control subjects over time from t1 to t4. Further, assume that the impact of the manipulation on males is different than the impact of the manipulation on females, thus creating different feelings of competence in females as opposed to males. Then differences between male and female Experimental groups can be attributed to differences in the expectation state the subjects are in.

Figure 35

Summary of Significant One-tailed t-Tests
for Differences in Unstandardized Laterality Indices
Between Female Control (-) and Female Experimental (-) Conditions

Comparison	t Value	df	Significance Level
t1	-	19	n.s.
t2	-	19	n.s.
t3 (Disagreements)	2.145	19	.025
t3 (Agreements)	1.894	19	.05
t4 (Disagreements)	1.534	19	.10
t4 (Agreements)	1.422	19	.10

This hypothesis can be tested using the P(s) data for Experimental subjects to see if there is a significant difference between males and females. Interview data from subjects immediately after the experimental session lend some support to this interpretation. Females much more often than males reported, even after having been told they were good at the task, that they just didn't think they had what it took to do this task. We may have chosen, then, a task which is culturally defined as being more ably accomplished by males than by females, and this may have had an overriding effect on our manipulation. No significant difference between males and females is found on the basis of P(s) scores, however. Thus, this interpretation cannot be adequately supported from the data, either.

E. Summary of Laterality Analysis by Cognitive Mode for the Three Stages

In this general, concluding section we will focus upon the data for which we have the most confidence: the Female Experimental and Control conditions. These were the last conditions in this series to be run. Both procedures and instrumentation were established by the time of these runs. As these two conditions were randomized, comparisons between the Experimental and Control are reliable, in addition to comparisons across decision epochs within a condition, holding subjects as their own control.

In analysis of the laterality indices for Female Experimental and Control conditions, we make the following observations:

1. Phase I decisions, t1 and t2, show no differences between Experimental and Control groups for either (+) or (-) cognitive mode subjects. This is reasonable since subjects in both conditions work alone; i.e., under the same conditions.

2. Laterality indices are significantly different between Experimental and Control groups for both (+) and (-) cognitive mode subjects in Phase II decisions; i.e., t3 and t4. This seems to indicate that the manipulation has a measurable effect on the laterality index of the Experimental subjects.
3. The effect of the manipulation apparently has a different directional effect on (+) as opposed to (-) cognitive mode subjects. Those in the (+) cognitive mode deviate from the Control group in the positive direction, while those in the (-) cognitive mode group deviate in the negative direction from their Control group. This observation can be seen graphically by reference to Figure 33.

These observations may be interpreted in the following manner. Under the pressure of social loading or social comparison, subjects work harder on the task than they would otherwise. Working harder on the task, in this context, seems to imply remaining in the same cognitive mode. Thus, subjects in the (+) cognitive mode become more positive, while subjects in the (-) cognitive mode become more negative.

The data on Male Experimental and Control support this interpretation only in the case of the subjects in the (+) cognitive mode. We are unable to say whether this represents a genuine difference between males and females in reaction to this particular experimental setting or if it is due to measurement error or alteration in facets of the experimental setting itself. Further studies should explore this issue. (For reference, means and standard deviations of laterality indices for all groups are given in Figure 36.)

These data suggest that there is no significant difference in laterality on agreement as opposed to disagreement trials. Whether this is actually the case or whether it is a function of the small number of

Figure 36

Mean Unstandardized Laterality Indices for Four Conditions by Decision Period and Initial Cognitive Mode (Standard Deviation in Parentheses)

Condition	Decision Period: Phase I t1	Phase I t2	Phase II t3	Phase II t4	
Positive t1 laterality coefficient:					
Female Cont. t1(+), N = 3	5.100 (3.315)	4.467 (5.795)	2.200 (3.740)	3.600 (5.151)	No Feedback
Female Exp. t1(+), N = 4	4.725 (2.494)	5.050 (1.613)	6.725 (2.371)	8.025 (2.666)	Disagreements
			5.800 (2.180)	9.275 (1.320)	Agreements
Male Cont. t1(+), N = 9	8.400 (5.200)	6.700 (4.207)	5.511 (3.681)	5.322 (4.527)	No Feedback
Male Exp. t1(+), N = 6	12.033 (12.171)	9.967 (9.171)	11.200 (10.183)	11.850 (11.023)	Disagreements
			12.177 (8.852)	10.450 (8.536)	Agreements
Negative t1 laterality coefficient:					
Female Cont. t1(-), N = 13	-6.660 (5.245)	-5.238 (5.311)	-3.377 (7.585)	-4.323 (7.528)	No Feedback
Female Exp. t1(-), N = 8	-8.800 (6.554)	-6.038 (5.780)	-10.350 (6.589)	-9.413 (7.129)	Disagreements
			-10.400 (9.285)	-9.138 (7.551)	Agreements
Male Cont. T1(-), N = 11	-5.718 (5.035)	-6.827 (4.407)	-7.464 (4.799)	-8.000 (4.911)	No Feedback
Male Exp. t1(-), N = 2	-4.450 (3.748)	-3.050 (2.899)	-2.250 (3.606)	1.450 (0.212)	Disagreements
			-4.950 (6.718)	2.800 (2.828)	Agreements

agreement trials resulting in unreliable measures, we are unable to say. A further study with equal numbers of agreement and disagreement trials should be able to resolve this issue.

One final observation seems appropriate. We have said that we are unable to make any statements regarding sex differences in laterality indices on the basis of the data presented. This is not entirely true. In the preceding analysis and discussion, we have focused upon changes in laterality indices over time and between conditions. We do not feel that cross sex comparisons are justified in the context of this analysis. However, it is worth noting the proportion of male and female subjects who approached this task in (+) and (-) cognitive modes. Of the 28 male subjects, 15 of them (53.6%) approached this task in a (+), right hemispheric, cognitive mode. Of the 28 female subjects, only 7 of them (25.0%) approached this task in a (+), right hemispheric, cognitive mode. A chi square test of this relationship is significant at the .05 level ($X^2 = 4.79$, df = 1). Thus, there appear to be sex differences in the cognitive mode with which males and females approach the Spatial Judgment task. Males are split almost evenly between right and left hemispheric cognitive modes. Females seem to prefer the left hemispheric cognitive mode.

We have demonstrated that lateralization of alpha is reactive to situations involving alterations in the social setting of decision-making. The data only partially support the original hypotheses. This suggests that under the conditions studied a somewhat different process is operating. The original hypothesis stated that the relative balance of hemispheric activity would be altered under social loading so that there would be a greater right hemispheric component. This hypothesis was supported

by only those subjects who approached the task in a predominantly right hemispheric cognitive mode. Subjects who approached the task in a predominantly left hemispheric cognitive mode showed a greater left hemispheric component in cognitive processing under social loading. This suggests that social loading increases the pre-existing differential in hemispheric activity or, in other words, causes one to go more deeply into whatever cognitive mode he is employing on the task.[6]

VI. CONCLUSION

In general, the results of this series of studies indicate that scalp-recorded alpha activity is reactive to the social environment. Specifically, we have shown a) that total alpha output responds systematically to the impact of social variables, and b) that lateralization of alpha activity also responds to the impact of social variables, particularly what we have called social loading.

We have taken total alpha output as an inverse indicator of task involvement. This seems to be a reasonable interpretation, since we found that a) alpha increased on final decisions, b) alpha increased from Phase I to Phase II, c) alpha was higher on agreement than on disagreement trials, and d) alpha was higher in Control than in Experimental conditions.

We have taken lateralization of alpha as an inverse indicator of relative hemispheric involvement on the task. Analysis on the aggregate level supports our initial hypothesis of a shift toward the right hemisphere under social loading. However, both sex and cognitive mode interact with the phenomenon. Controlling for cognitive mode with which the subjects approached the task, we found that under conditions of social loading hemispheric lateralization was increased in a direction consistent with individual lateralization preference on the task when working alone.

There are many directions future work could fruitfully take.

We have suggestions from the data of two potentially exciting areas of inquiry within this experimental setting. First, it seems that anticipation of social interaction as well as actual social interaction may impact on hemispheric balance. Second, it appears that the setting itself serves to diminish initial differences between the sexes.

Future research should manipulate subjects into differential expectation states to determine the lateralization effect of moving into one or another expectation state. Subjects manipulated into differential expectation states should be even more reactive to social loading than was the case in this series of studies. In this paradigm, we could also make use of the rates of influence in Phase II to interpret lateralization data against a background of substantial behavioral data which has already been collected in this experimental setting. In this report, we have not approached the question of trial-by-trial analysis, which might reveal interesting insights into proceses which occur over time in changing lateralization of alpha.

It may be fruitful to investigate the effect of other forms of social loading on lateralization of alpha. Conformity and normative behavior as studied in the Asch and Sherif experimental settings seem obvious choices. Both of these settings could be easily adapted to allow for the measurement of alpha lateralization.

In addition to suggesting new research questions, the present series of studies suggest at least two procedural changes. One involves the choice of recording sites. There is evidence that suggests that the occipital region used for recording in this study may not be the most reactive site for measuring the impact of social variables. Recordings from the temporal and parietal areas may be found to be more reactive. In addition, equipment which permits the entire EEG spectrum to be recorded and analyzed by components would improve the methodology. The other change which seems to be suggested by this series of studies is to either a) increase the number of subjects per condition, so that individuals who approach the task in different cognitive modes can be separated out for

analysis, or b) select a task which is more uniformly processed in a single cognitive mode by subjects.

In summary, we are encouraged by the present studies which suggest that both total alpha output and lateralization of alpha are reactive to social parameters. These studies investigate substantively interesting questions and demonstrate a useful research tool. We believe that in investigations of this kind we are approaching the very fundamental question of how persons are able to orient themselves to varying social environments.

FOOTNOTES

[1]The capacity for lateralization in nonhuman primates is not yet established, although it is clear that humans are the most highly lateralized of primates. It is possible that this evolutionary development contributes to the richness of human social life in comparison with other species. Jaynes, in The Origin of Consciousness in the Breakdown of the Bicameral Mind, equates utilization of the capacity for lateralization with differences in consciousness and culture (Jaynes, 1977). Nobel price-winning neurophysiologist Eccles suggests that lateralization of hemispheres makes possible human ethical constructions (Eccles, 1976).

[2]The broad objective of the work which has been done to date by other investigators has been to correlate hemispheric activity with well-defined specific tasks. Presumably, a knowledge of the specializations of the separate hemispheres in normal people would lead to a greater understanding of how the brain interacts with the environment to produce patterned behavior. However, this link has been only indirectly established.

We believe that certain correlates of hemispheric activity have implications for not only individual but also interactive behavior. For example, it has been shown that the right hemisphere is associated with the perception and recognition of facial expressions (Harmon, 1973; Levy, Trevarthen and Sperry, 1972), and it has recently been shown that facial cues are instrumental to status formation in face-to-face groups (Rosa, 1976). This association is potentially important for understanding face-to-face interaction, since impressions of another are likely a factor

which influences the structure and direction of communication between interactants. (ER)

[3]An example from clinical investigations of persons in whom the hemispheres are not connected may serve to provide a holistic understanding of the basic process we think is operant for the social realm. Gazzaniga presented a detached-hemisphere patient with a cognitive task of matching an item to an appropriate superordinant, associated category. If the item, pear, was presented to the left brain (by tachistoscope), the patient correctly said "pear matches fruit"; if presented to the mute right brain, the patient correctly pointed to the appropriate match. Gazzaniga asked the left brain of the patient for a match to a chicken claw, and the patient correctly responded with "chicken coop." The right brain correctly, by pointing, matched snow to snow shovel, and the choice was observed by the left brain. Gazzaniga then asked "why?" A moment of puzzlement on the part of the patient (remember, the hemispheres of the patient could not communicate as they were not connected, and only the left brain is verbal) and the patient responded, "I need the shovel to clean out the chicken coop." (Gazzaniga, 1976). It is a process similar to this that we want to investigate in normal subjects with social phenomena.

[4]We believe that social categories, including stereotypes, are basically right-brain constructions used in orienting the individual to his or her social world. Gestalt perceptions of the social world of relationships become rationalized by the left brain. (Note: The right brain is reputed to have a few words that are words of greeting, such as

"hello," "how are you," and swear words. We take them to be words which express the general orientation of the actor in relation to a perceived situation.)

We believe that social forms occur across eras, cultures, and peoples and have recognizable characteristics in much the same way that linguists argue for "deep structures" in language which are identifiable across particular languages. It is our belief that humans have the genetic capacity to perceive, create, and participate in social forms analogously to the human's capacity for language acquisition and production. Cultures and individual experience react with this capacity to produce the remarkable variation and elaboration of expression of social forms, and the content they come to have.

We believe that humans perceive social structure and that the perception is either accompanied by or immediately followed by a "*matching*" through which the individual places himself or herself within the structure. By that act, the individual has established his or her structural relationship to other actors in the system.

We therefore hypothesize that perceiving social structural relationships is primarily a right brain process (similar to real spatial orientation) and that the left brain brings to bear the appropriate cultural and normative interpretative and behavioral codes necessary for the individual to interact. This capacity should be particularly demonstrable in small group interaction. (PB)

[5]We have suggested that the right hemisphere is predominant in orienting the actor to certain elements of social interaction. For the present purposes, it is convenient to think of the left hemisphere as that

which processes information for which there is a logical-analytical-rational algorithm readily available in making a decision. The right hemisphere is conceived of as that hemisphere which processes information which may be pertinent to a decision, but for which there is no logical-analytical-rational algorithm available. Thus, given a social interaction situation in which an individual has to make a decision, there may be two different kinds of pertinent information in the setting: analytic and nonanalytic. Information perceived as relevant to the decision which requires analytic skill in making use of the information will be processed predominantly by the left hemisphere. Information perceived as relevant to the decision which requires some kind of nonanalytic skill in making use of the information most likely will be processed predominantly in the right hemisphere.

There is no analytic algorithm available to handle many kinds of social information. For example, in the absence of other information, there exists no way to logically evaluate the fact that, in attempting to solve a nonobjective problem, another person is in disagreement with you. While an analytic algorithm is certainly possible for such social influence information, it most likely would require a considerable amount of data pertaining to the background of the disagreeing individual and his history of performance in similar decisions in the past. Alternatively, it would require definite expert knowledge of the objectively correct solution to the problem. When this kind of information is not available, i.e., when no analytic algorithm can be constructed, the information may be processed in a more right hemispheric fashion. This means that the laterality index of the decision would have stronger right hemisphere component than if the social influence information had not been present in the decision context.

There may be conditions under which it is possible to construct analytic algorithms for seemingly nonanalytic social information. We call an analytic algorithm so constructed an analytic transform, because it allows one to transferm the problem in such a way that seemingly non-analytic social information can be processed in an analytic or left hemispheric manner. One type of analytic transform may be an expectation state (Berger et al., 1974). An expectation state is formed on the basis of status information which differentiates interactants. Such knowledge, particularly knowledge relating to performance abilities on the task in question, may well provide a means of constructing an analytic transform for social influence information. For example, if a subject knows that he is very capable on a particular task, and that his partner is particularly inept, then he will be in an expectation state in which he will expect to do much better on the task than his partner, and will evaluate his own answers more highly than those of his partner. In social comparison, or social influence situations such as this, there is a simple analytic transform for dealing with the social influence information so that it can be processed in the left hemisphere. The transform rule might be stated as follows: "When we disagree, I'll stick with my own answer." When such an operational rule for making a decision is invoked, the left brain can easily execute the analytic steps necessary to come to a decision. Thus, this particular kind of situation (where performance abilities are known) converts what otherwise would have been information which only could be processed by the right hemisphere, into information which can be processed by the left hemisphere.

Thus, we believe that social information is often such that it cannot be processed in analytic left hemispheric mode. It is possible, however,

under specifiable conditions (i.e., in the presence of a differentiated expectation state) that an analytic transform can be brought to bear on the processing of social information. This assumes that the left cognitive mode is the preferred mode for decision-making and will be invoked whenever possible. This may be culturally determined, but in Western industrial culture seems intuitively to be the case. Our schooling, for instance, to which we subject children for a minimum of twelve years, emphasizes almost exclusively analytic decision-making.

If the foregoing analysis is substantially correct, it has significant implications for the ubiquity and power of general social processes such as stereotyping, scapegoating, ethnocentrism, and prejudice. In light of the foregoing discussion, these processes can be seen as providing analytic transforms for certain types of social information which, while thought to be important to some decision-making contexts, are difficult to evaluate analytically. The transforms provided by these processes establish simple (perhaps simpleminded) and preferred analytic decision-making rules which serve to define and clarify potentially complex social situations. One would expect great resistance to modification of attitudes or behavior based upon such transforms, because modification would require not only coping with a larger amount of information but also would require coping with the harder-to-evaluate (from an analytic perspective) right hemispheric information. In addition, since these transforms are derived from the right hemisphere, which is not specialized for critical analytic thinking, they may be all the more resistant to change, since empirical data or persuasive argument have no way of bearing directly on the modification of the transform. (WSJ II)

[6]This observation may help explain why social pressure to change an attitude or a behavior is sometimes successful and sometimes only strengthens the attitude or behavior. For example, if the attitude or behavior is based upon nonanalytic cognitive processes, social pressure (social loading) may strengthen the right hemispheric cognitive mode, reinforcing nonrational support for the attitude or behavior, thus making it more resistant to change. However, if the attitude or behavior is based upon analytic cognitive processes, social pressure may strengthen the left hemispheric cognitive mode, opening the attitude or behavior to modification by rational persuasion. This would suggest that rationally-founded attitudes and behaviors may best be modified by rational discourse and argument, but that nonanalytically-based (i.e., nonrationally-based) attitudes and behaviors may be capable only of modification by nonrational, right hemispheric appeals.

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APPENDIX A: STANDARDIZED LATERALITY INDEX ANALYSIS BY COGNITIVE MODE

Standardized laterality indices are standardized for each individual by reference to the normal resting, or non-task, laterality index of the individual. They are computed by taking the unstandardized laterality index and subtracting from it the laterality index based on the baseline measurement periods (the baseline laterality index). Letting ULI stand for unstandardized laterality index and BLI stand for baseline laterality index, the standardized laterality index (SLI) is given by the following formula: SLI = ULI - BLI.

For each individual, a baseline laterality index is computed for Phase I and again for Phase II. Baseline measurements are taken before each slide series and after every five slides. Each baseline measurement period is thirty seconds long, during which the subject is instructed to keep his eyes open but to try to relax and not to think of anything in particular. (The exception to this is that baselines in the Male Experimental condition were taken with the eyes closed.) Standardized laterality indices for each individual on each trial are calculated by subtracting the appropriate baseline (Phase I or Phase II) from the unstandardized laterality index. Standardized laterality indices are then aggregated in the same manner as was described for unstandardized laterality indices: first, across trials for a subject; then, across subjects for a condition. Thus, we have standardized laterality indices for each decision epoch in each condition. This is the data upon which this analysis is based.

A. Stage One: Male Experimental Condition

1. Data

Figure 37 presents the standardized laterality indices averaged across subjects for each decision epoch: a) for all subjects combined, b) for subjects with positive t1 standardized laterality indices, ME(+), and c) for subjects with negative t1 standardized laterality indices, ME(-). There are three subjects with positive t1 standardized laterality indices and five subjects with negative t1 standardized laterality indices.

We begin by considering the group with the greatest number of subjects, ME(-). Statistical tests across decision epochs are summarized in Figure 38. In spite of the small number of subjects (N = 5), we find significant differences in four comparisons. There is a significant increase between t2 and t3 on disagreement trials. All subjects (five) increased in this comparison. There is also a significant increase from t3 to t4 for agreement trials. Four of the five subjects increased in this comparison. Four of five subjects also increased on the t2 to t3 agreement comparison, and on the t3 to t4 disagreement comparison, but these differences are not statistically significant. In addition, no significant difference was found between agreement and disagreement trials.

We now consider differences between phases. No significant difference was found between initial choices in Phase I and Phase II. Significant differences were found, however, between final choices in Phase I and Phase II for both agreement and disagreement trials. On agreement trials, four of the five subjects increased. On disagreement trials, all subjects increased.

In spite of the small number of subjects in the ME(+) group (N = 3),

Figure 37
Standardized Laterality Indices by Decision Epoch for Male Experimental Condition

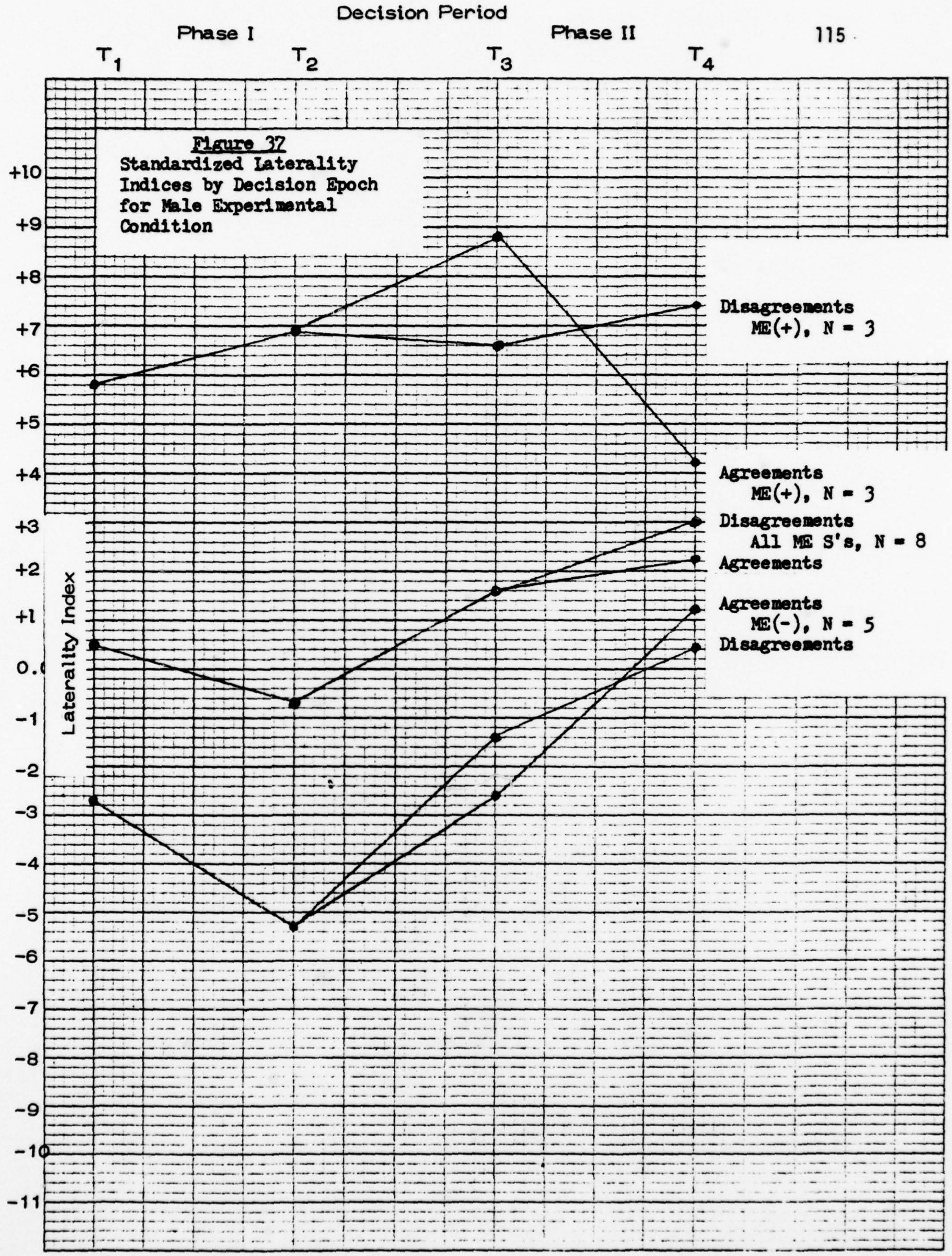

Figure 38

One-tailed t-Tests on Differences in Standardized Laterality Indices for Male Experimental (-) Subjects

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	-	4	n.s.
t2 vs. t3 (Agreements)	-	4	n.s.
t2 vs. t3 (Disagreements)	2.059	4	.10
t3 vs. t4 (Agreements)	1.980	4	.10
t3 vs. t4 (Disagreements)	-	4	n.s.
Between phases:			
t1 vs. t3 (Disagreements)	-	4	n.s.
t1 vs. t3 (Agreements)	-	4	n.s.
t2 vs. t4 (Disagreements)	2.331	4	.05
t2 vs. t4 (Agreements)	4.631	4	.005

there were significant differences in two comparisons (see Figure 39). There was a significant difference between agreement and disagreement trials at t4 (all three subjects were lower on agreement trials). There was also a significant decrease from final decision Phase I to final decision Phase II for agreement trials (all three subjects decreased).

2. <u>Interpretation</u>

On the basis of the unstandardized laterality indices, we suggested that novelty (first choice) and complexity (disagreements and/or presence of a partner) increase laterality indices. This conclusion is partially supported by the standardized laterality index analysis as well. The drop in laterality index from t1 to t2 for t1 (-) subjects (N = 5), while not significant, is in the correct direction, with three of the five subjects changing as expected. Similarly, the increase from t2 to t3 is consistent with this interpretation. Four of five subjects increased on agreement trials; all five increased on disagreement trials. The increase was significant for disagreement trials.

The laterality index at t4, however, is not lower than that at t3, as would be consistent with our interpretation. Four of five subjects increased from t3 to t4. It is possible that this increase is a result of sustained complexity in the final decision due to the presence of the partner's opinion. In any case, this data is in conflict with the pattern presented by the unstandardized laterality indices.

It should be noted, however, that we are comparing standardized laterality indices for subjects who were initially negative, with unstandardized laterality indices for subjects who were initially positive. We did this because these are the larger of the two groups, respectively. It is

Figure 39

One-tailed t-Tests on Differences
in Standardized Laterality Indices
for Male Experimental (+) Subjects

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	-	2	n.s.
t2 vs. t3 (Disagreements)	-	2	n.s.
t2 vs. t3 (Agreements)	-	2	n.s.
t3 vs. t4 (Disagreements)	-	2	n.s.
t3 vs. t4 (Agreements)	-	2	n.s.
Between phases:			
t1 vs. t3 (Disagreements)	-	2	n.s.
t1 vs. t3 (Agreements)	-	2	n.s.
t2 vs. t4 (Disagreements)	2.85	2	.10
t2 vs. t4 (Agreements)	-	2	n.s.
Agreements vs. Disagreements at t4			

possible, however, that positive and negative starters do not act in exactly the same way to the experimental setting. It appears that there is, roughly speaking, a mirror image difference between positive and negative starters on both standardized and unstandardized measures.

B. Stage Two: Male Control Condition

1. Data

Figure 40 presents standardized laterality indices by decision epoch for: a) all male control subjects, b) subjects with positive t1 standardized laterality indices, MC(+), and c) subjects with negative t1 standardized laterality indices, MC(-). We note, first of all, that the Male Control (-) group (N = 6) shows an increase in standardized laterality indices over time, in contrast to both the standardized Male Control (+) and the unstandardized MC (+) and (-). This is due to a decrease in the baseline laterality index from Phase I to Phase II for every one of the six subjects in this group. Only half of the Male Control (+) subjects had a decrease in baseline laterality index from Phase I to Phase II. The pattern of results here follows the mirror image pattern noted previously.

Statistical tests for differences between decision epochs for the Male Control (+) and (-) on standardized laterality indices are given in Figures 41 and 42, respectively. Once again we are presented with an inconsistent pattern of results.

2. Interpretation

There is evidence for a general trend downward in standardized laterality indices for the MC (+) group and an upward trend for the MC (-)

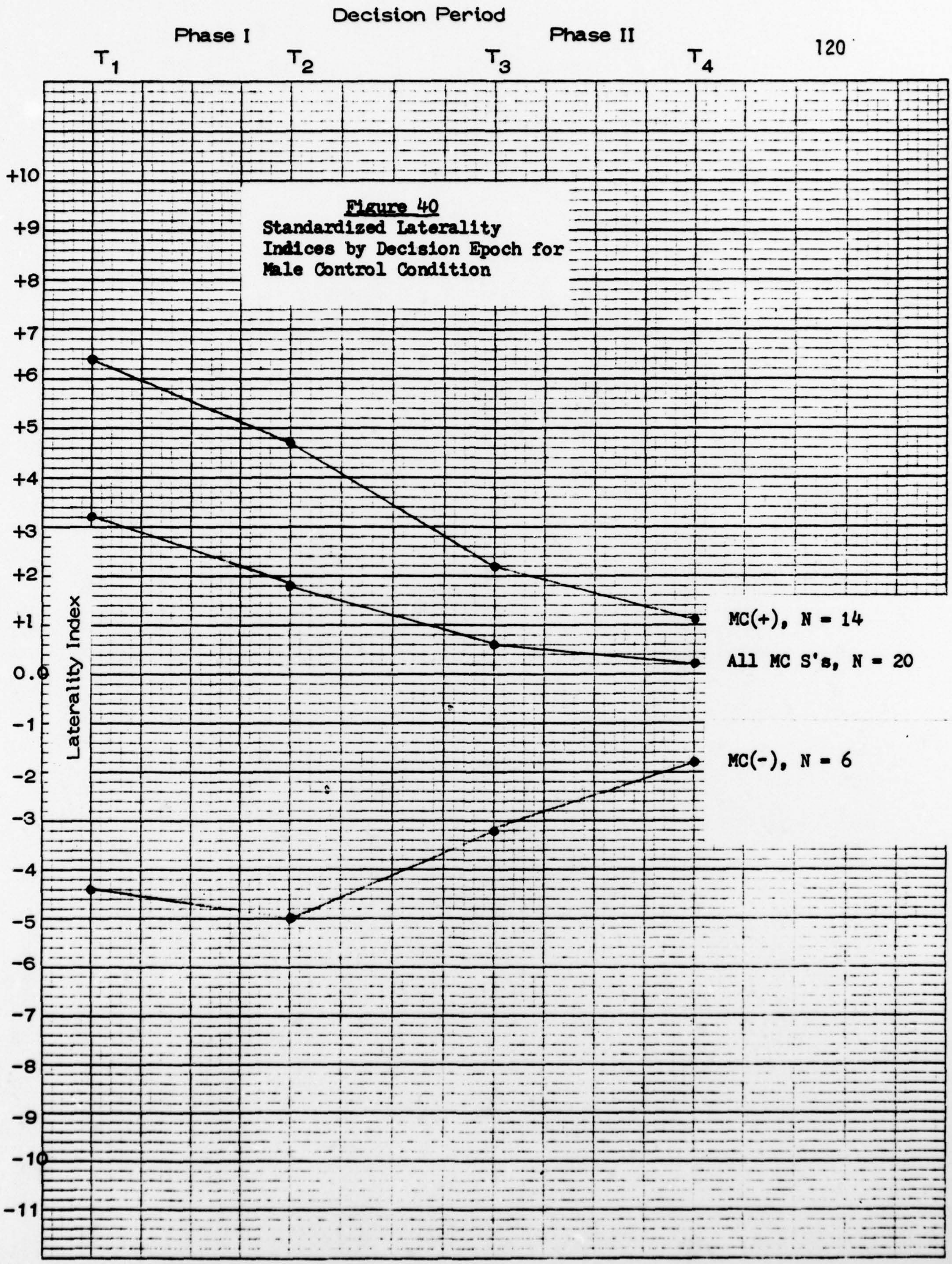

Figure 40
Standardized Laterality Indices by Decision Epoch for Male Control Condition

Figure 41

Summary of Significant One-tailed t-Tests
on Differences in Standardized Laterality Indices
for Male Control (+) Condition (N = 14)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	3.148	13	.005
t2 vs. t3	-	13	n.s.
t3 vs. t4	1.693	13	.10
Between phases:			
t1 vs. t3	-	13	n.s.
t2 vs. t4	-	13	n.s.

Figure 42

Summary of Significant One-tailed t-Tests
on Differences in Standardized Laterality Indices
for Male Control (-) Condition (N = 6)

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	-	5	n.s.
t2 vs. t3	1.885	5	.10
t3 vs. t4	1.485	5	.10
Between phases:			
t1 vs. t3	-	5	n.s.
t2 vs. t4	3.055	5	.025

group. This is the mirror image phenomenon noticed earlier. The pattern here is distinctly different than for the unstandardized laterality indices.

Thus, the data for the (-) subjects is inconsistent with the hypothesis that novelty, complexity, and/or social loading increase the laterality index.

C. Comparison of First and Second Stages

It is inappropriate to make comparisons across the Control and Experimental conditons on the standardized laterality index measure, because the two conditions are standardized to different kinds of baseline measures and were not run in a signal design. The Experimental subjects were standardized to an eyes-closed baseline while the Control subjects were standardized to an eyes-open baseline. Ideally, baseline measurements would be taken under conditions as close as possible to the task conditions. Since the task employed here requires the subject to keep his eyes open so he can see the stimulus slides, the eyes-open baseline is probably the more appropriate.

D. Stage Three: Female Experimental and Control Conditions

1. Data

Figure 43 plots standardized laterality indices by decision epoch for Female Control (+), (-), and all Female Control subjects. In the case of the Female Control (+), we notice a general downward trend over time in the standardized laterality indices, but none of the comparisons is statistically significant, apparently due to wide variance.

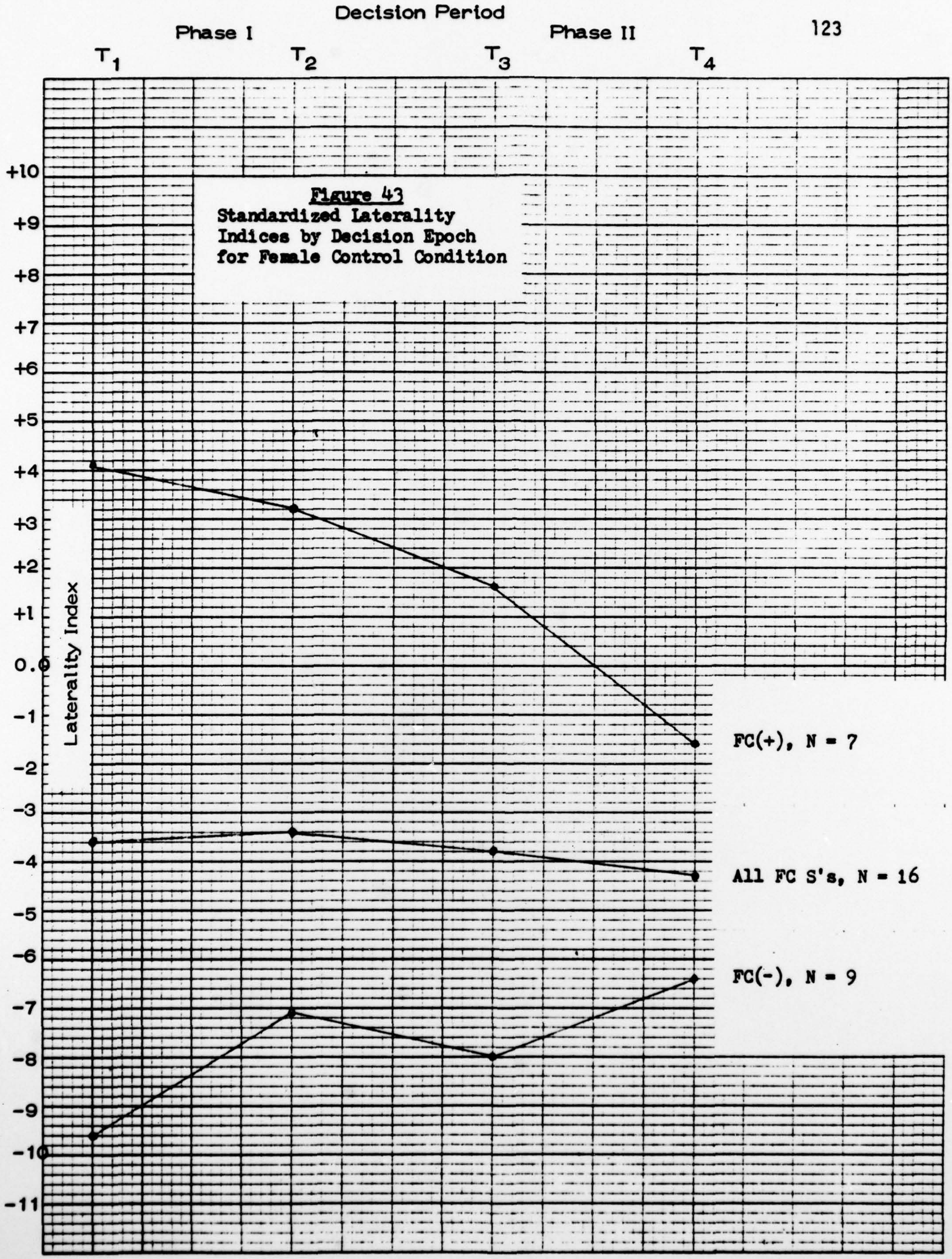

Figure 43
Standardized Laterality Indices by Decision Epoch for Female Control Condition

In the Female Control (-) situation, the picture is quite different. However, there is only one significant comparison in this situation: the increase from t1 to t2 (see Figure 44).

Our best guess is that this data shows no change over time in either the Female Control (+) or the (-) conditions.

Standardized laterality indices for the Female Experimental (+) and (-) groups are plotted in Figure 45. Statistical analysis of the Female Experimental (+) condition is meaningless due to the fact that there are only two subjects in this condition. Therefore, we focus on the Female Experimental (-) condition. Here we see a pattern similar to that of the Female Control (-). As in that case, only one comparison is statistically significant: the increase from t1 to t2 (see Figure 46).

These data do not show much in the way of statistical significance. The ordinal pattern which appears in the Female Control (-) is the same as in the Female Experimental (-). This is only interpretable if we assume that the manipulation and presence of a partner had no effect on the subjects. This seems implausible.

Figure 47 graphs Female Control and Experimental, (+) and (-), standardized laterality indices. Comparing Female Experimental (+) and Female Control (+), we see that the Phase I scores, t1 and t2, are not statistically different but that the Phase II scores, t3 and t4, are significantly higher for the Experimental group. Statistical tests are summarized in Figure 48. This is consistent with the notion that the added complexity or social loading in Phase II increases the laterality index.

Figure 49 presents a summary of the statistical tests for differences between the Female Control (-) and Female Experimental (-) conditions. Only one significant difference is found, between t4 for the Controls and

Figure 44

Summary of Significant One-tailed t-Tests

on Differences in Standardized Laterality Indices

for Female Control (-) Condition, N = 9

Comparison	t Value	df	Significance Level
Between trials:			
t1 vs. t2	1.70	8	.10
t2 vs. t3	-	8	n.s.
t3 vs. t4	-	8	n.s.
Between phases:			
t1 vs. t3	-	8	n.s.
t2 vs. t4	-	8	n.s.

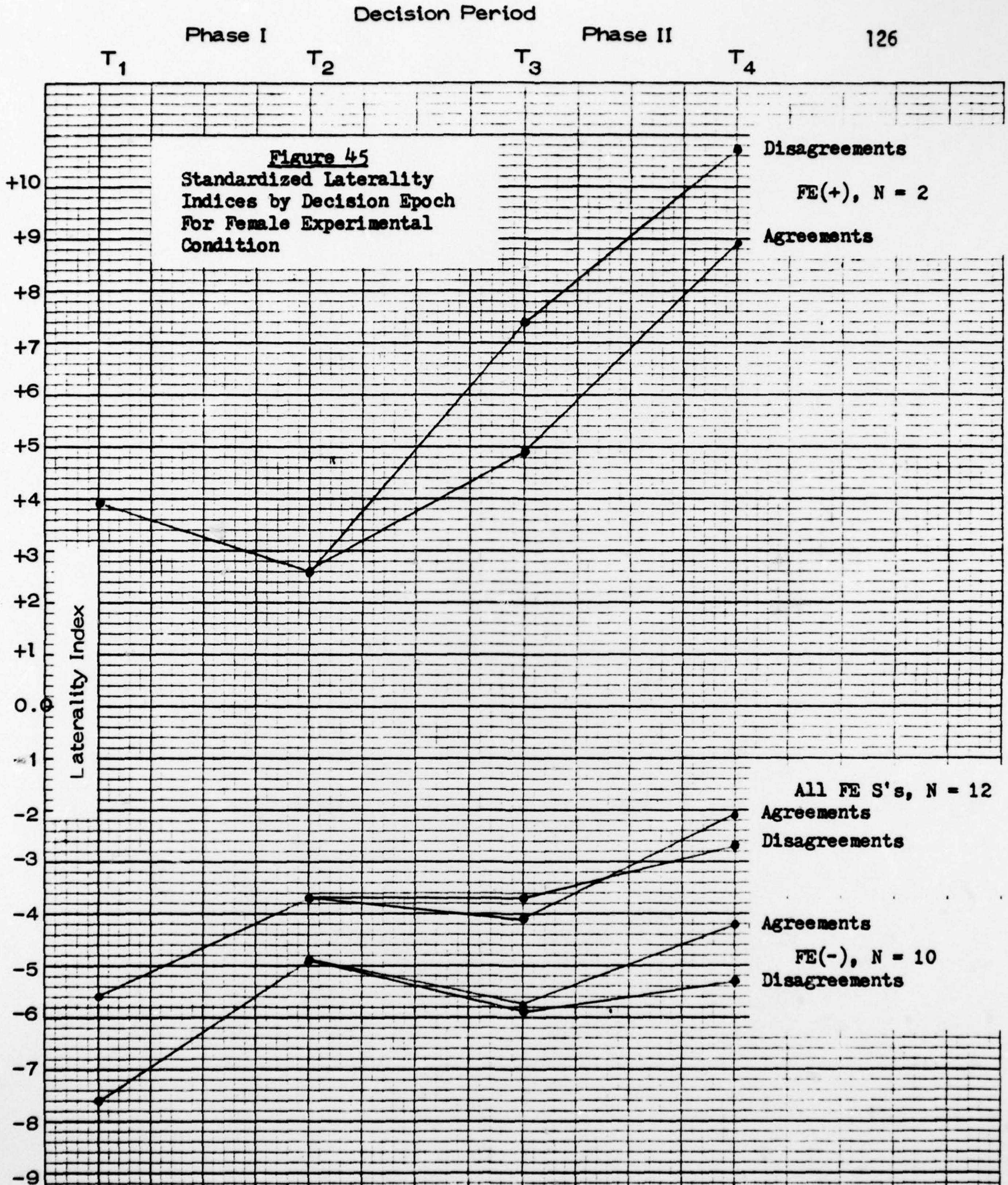

Figure 45
Standardized Laterality Indices by Decision Epoch For Female Experimental Condition

Figure 46

Summary of Significant One-Tailed T-Tests on Differences in Standardized Laterality Indices for Female Experimental (-) Condition (N = 10)

Comparison	T Value	df	Significance Level
Between decisions:			
T1 vs. T2	1.996	9	.05
T2 vs. T3 (Disagreements)	-	9	n.s.
T2 vs. T3 (Agreements)	-	9	n.s.
T3 vs. T4 (Disagreements)	-	9	n.s.
T3 vs. T4 (Agreements)	-	9	n.s.
Between phases:			
T1 vs. T3 (Disagreements)	-	9	n.s.
T1 vs. T3 (Agreements)	-	9	n.s.
T2 vs. T4 (Disagreements)	-	9	n.s.
T2 vs. T4 (Agreements)	-	9	n.s.

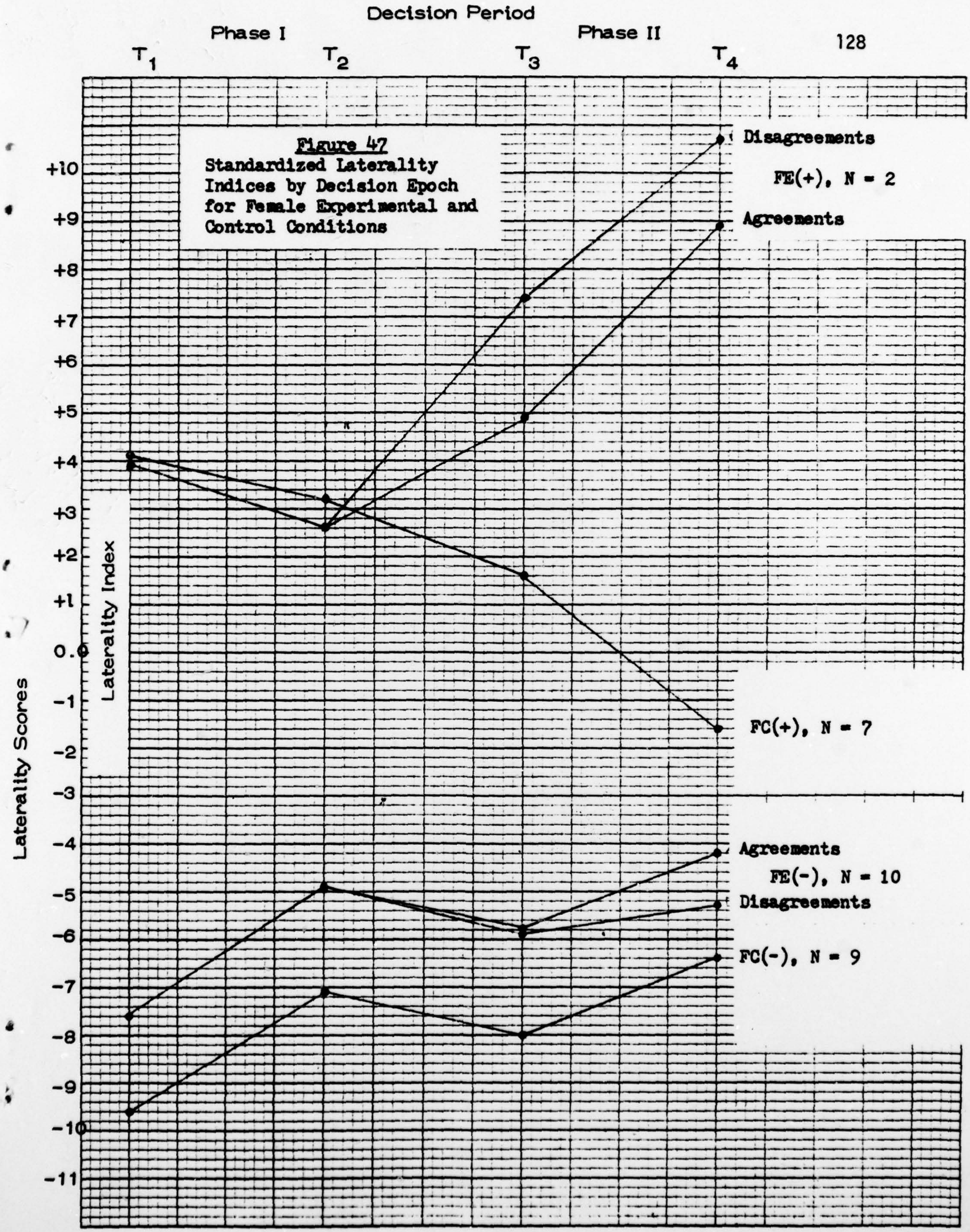

Figure 47
Standardized Laterality Indices by Decision Epoch for Female Experimental and Control Conditions

Figure 48

Summary of Significant One-tailed T-Tests
for Differences in Standardized Laterality Indices
Between Female Control (+) and Female Experimental (+) Conditions
by Decision Period

Comparison	T Value	df	Significance Level
T1	-	7	n.s.
T2	-	7	n.s.
T3 (Disagreements)	1.585	7	.01
T3 (Agreements)	-	7	n.s.
T4 (Disagreements)	2.612	7	.025
T4 (Agreements)	1.714	7	.10

Figure 49

Summary of Significant One-Tailed T-Tests
for Differences in Standardized Laterality Indices
Between Female Control (-) and Female Experimental (-) Conditions
by Decision Period

Comparison	T Value	df	Significance Level
T1	-	17	n.s.
T2	-	17	n.s.
T3 (Disagreements)	-	17	n.s.
T3 (Agreements)	-	17	n.s.
T4 (Disagreements)	-	17	n.s.
T4 (Agreements)	2.044	17	.05

t4 on agreement trials for the Experimentals. Our conclusion from this is that the Experimental manipulation seems to have had no effect.

2. Interpretation

In the data set consisting of females (Experimental and Control), we find that the standardized laterality indices do not seem to tell as nice a story (form as consistent a picture) as the unstandardized laterality indices. It could be that the baseline laterality indices change from Phase I to Phase II in such a way that when these changes are controlled for, as in calculating standardized laterality indices, differences in laterality caused by the condition are wiped out. That is, one of the effects of the social status and social comparison variables we are studying may be a changed baseline. If we control for that, we may be missing a potentially important effect. We do not present an analysis of this data but, for informational purposes, changes in baseline laterality indices from Phase I to Phase II are graphed in Figure 50. Means and standard deviations are given in Figure 51.

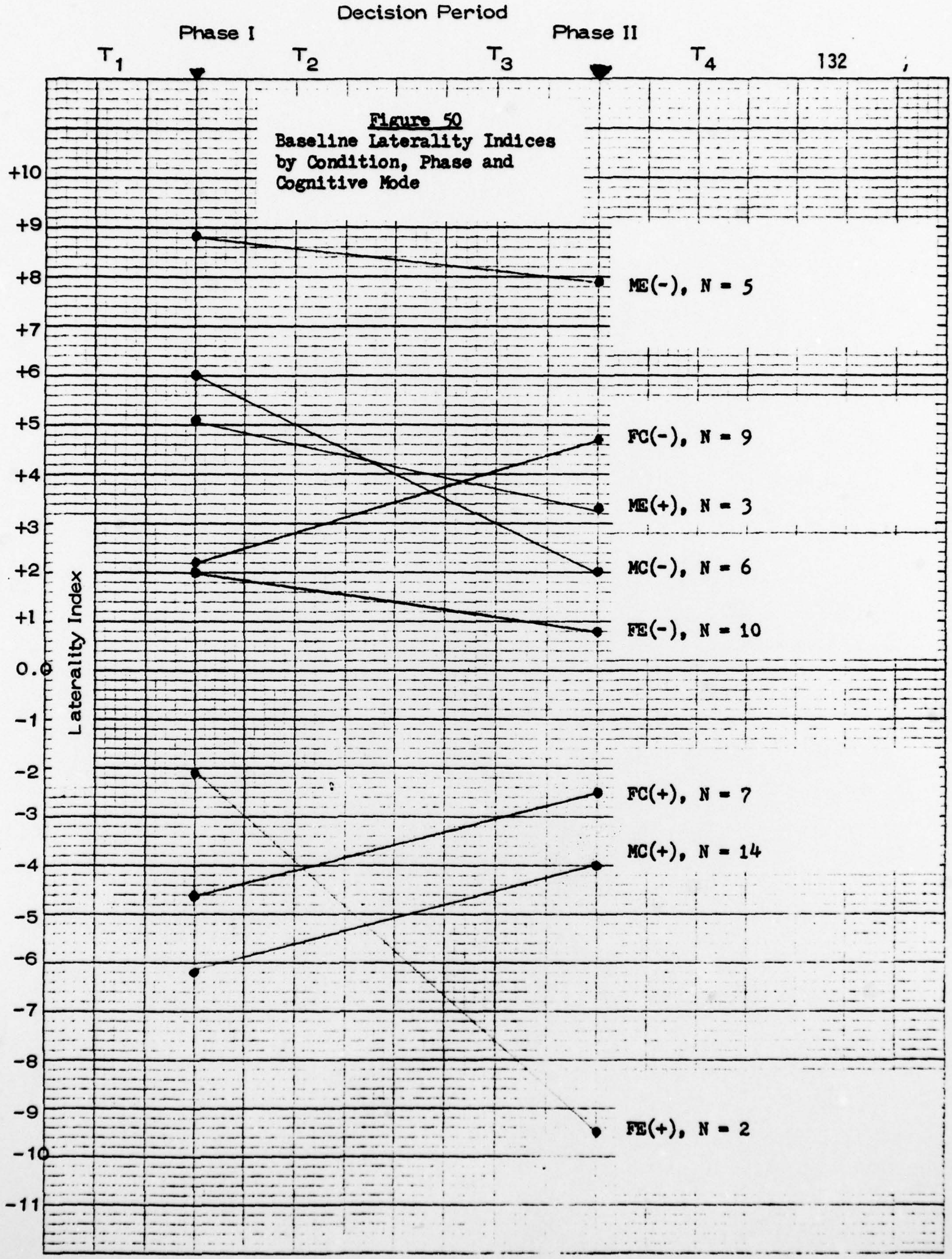

Figure 50
Baseline Laterality Indices by Condition, Phase and Cognitive Mode

Figure 51

Baseline Laterality Indices
by Condition, Phase, and Initial Cognitive Mode (SLI)
(Standard Deviation in Parentheses)

Condition		Phase I	Phase II
Female Control	T1(+) N = 7	-4.591 (7.327)	-2.523 (6.051)
	T1(-) N = 9	2.154 (4.683)	4.563 (5.873
	Total N = 16	-0.797 (6.717)	1.463 (6.799)
Female Exper.	T1(+) N = 2	-2.090 (5.049)	-9.530 (2.477)
	T1(-) N = 10	2.033 (11.056)	0.774 (10.185)
	Total N = 12	1.346 (10.242)	-0.943 (10.075)
Male Control	T1(+) N = 14	-6.161 (8.059)	-4.027 (14.910)
	T1(-) N = 6	5.963 (8.305)	2.027 (10.291)
	Total N = 20	-2.524 (9.751)	-2.211 (13.714)
Male Exper.	T1(+) N = 3	5.167 (10.350)	3.337 (9.000)
	T1(-) N = 5	8.812 (15.263)	7.934 (16.317)
	Total N = 8	7.445 (12.934)	6.210 (13.452)